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CIS

FISCAL YEAR 1990 DEPARTMENT OF ENERGY AUTHORIZATION

(Nuclear Fission)

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

MARCH 1, 1989

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1990 DEPARTMENT OF ENERGY AUTHORIZATION

WEDNESDAY, MARCH 1, 1989

U.S. House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Energy Research and Development,
Washington, DC.

The Subcommittee met at 1:10 p.m., in Room 2318, Rayburn House Office Building, Hon. Marilyn Lloyd, Chairman, presiding.

Present: Representatives Lloyd, Stallings, Morrison, Fawell, Walker, Smith, and Schiff.

Also present: Louis Ventre, Counsel; Nelson L. Milder, Technical Consultant; and Kitty H. Rising, Rep. Special Assistant.

OPENING STATEMENT OF HON. MARILYN LLOYD, CHAIRPERSON, SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

Mrs. Lloyd. The Subcommittee will come to order. I do apologize for being late. This hasn't happened before, I don't believe. There seems to be about three things going on at one time today.

Before we begin today, I do ask unanimous consent that the Subcommittee permit today's proceedings to be recorded by the media and others and, without objection, so ordered.

This afternoon we are considering the Administration's request for Nuclear Energy Research and Development. This request totals approximately $351 million and is composed of the Light Water Reactor program, the Advanced Reactor Research and Development program, the Space and Defense Power Systems program, and Advanced Nuclear System program and facility support component.

I do note that the facilities portion of the budget is the single largest component of the Nuclear Energy R&D budget, totaling about 51 percent of the request in this budget category. This is significant because the mortgages associated with existing facilities at our national laboratories are becoming a significant part of the year-to-year budget in the nuclear fission R&D category.

It is of significant concern because research and development activities that have been funded in this budget category are shrinking to such a degree that the program continuity is being challenged. This is a most distressing and difficult question for the Subcommittee and certainly it will be addressed at our hearing today.

Of significant note in the Light Water Reactor R&D program is that the budget request is significantly lower than would be the case if the Department complied with its own agreement with industry. The Department of Energy made these agreements with certain industry participants and has requested a level that is inadequate to comply with the funding level anticipated in the contracts. This is certainly a curious inconsistency which we hope that the Department will explain today.

Concerning the Advanced Reactor Research and Development program, the Department of Energy shaved $43 million from its fiscal year 1989 budget appropriation. Now, this is literally at a closeout level for many of the program activities. This also is inconsistent with recent agreements between the Department of Energy and the industrial participants in the program.

Additionally, the Department of Energy cites as a reason for the proposed reduction the expectation of more funds provided by international partners. This reasoning challenges their credibility, in that the international partners are expected to reevaluate their commitment to the program given the Department's severe curtailment of its contributions to the program.

Now, on a positive note, Consumer Power Company is taking steps to examine the options for electricity production from the MHTGR technology. We commend them for their insight in examining the use of an inherently safe reactor nuclear technology and we certainly welcome their leadership.

In the Space and Defense Power Systems program, the Administration recommends a $21 million reduction over the FY '89 budget. This restructuring of the program stretches out the schedule for the SP–100 Ground Engineering System and ultimately increases the cost of the project. We will be anxious to understand why it's appropriate to change the program plan for the power system, considering that both the Strategic Defense Initiative Office and NASA are contributing a substantial amount of money to develop the SP–100 system.

The Advanced Nuclear Systems category is recommended for a substantial $23 million increase to provide the facilities necessary to support non-reactor space mission power systems. A key issue here relates to the future production capability of Plutonium–238 fuel for these systems.

And, finally, the facilities budget, the mortgages for operating program facilities, is up by $42 million to $180 million. The increases are primarily for enhanced safety and fuel supply activities associated with FFTF and ERB–II and for completion of the hot fuel examination facilities at Argonne West.

Despite the significant increase in facilities support, we are at a closeout level for the operation of the Energy Technology Engineering Center in California. This had been an important facility and I am sure we will be hearing more about its role and what we will lose with this budget from the witnesses.

The Nuclear Energy R&D program activities budget is significantly underfunded this year. I've already mentioned some of the reasons for this. It seems quite clear that this Subcommittee is going to be faced with a number of serious questions concerning the level of support for the technologies under this category, and we hope to air all of these issues at the hearing today.

But before we do begin, I would like to yield to the distinguished Ranking Republican Member of this Committee, the gentleman from Washington whose advice and counsel and certainly his participation in this Subcommittee's proceedings I do value dearly.

Sid.

OPENING STATEMENT OF HON. SID MORRISON, RANKING REPUBLICAN, SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

Mr. **Morrison**. Thank you very much, Madam Chairman.

The subcommittee is on a fast track from a budgeting point of view, and I look forward to this afternoon's session, which is one of the most important that we'll be holding as we look at the Nuclear Fission Research and Development program.

I can tell everyone here that there has been a tremendous increase in Congressional interest in global climate change. Nuclear energy is considered one of the alternatives, the most important one as far as we're concerned, to mitigate this so-called greenhouse effect. But to make nuclear energy truly viable, we need to increase passive safety features, simplify the design and construction of modular and standardized reactors and find innovative ways to manage radioactive waste.

Our nation's Nuclear Energy R&D program is in the best position to carry out these missions and provide answers to those public involving public attitude, economics and licensing, so that nuclear energy can indeed play a key role in our future energy mix.

I am pleased with the progress made in advanced reactor programs. The Liquid Metal Reactor program has completed several impressive tests to demonstrate inherent safety features, and I am particularly proud of the accomplishments of the Fast Flux Test Facility (FFTF). FFTF broke the world record in both continuous operation and capacity factor for a liquid metal reactor.

I am also aware of the progress being made with the High Temperature Gas Reactor (HTGR). The Subcommittee can be proud of these activities.

I have to mention a major concern of mine, Madam Chairman, is in the area of space and nuclear power development. It's been a continuous struggle to maintain an appropriate funding level for the SP-100 program. Both NASA and the Department of Defense want it, but neither one is willing to pay their fair share of the development costs: a song we hear over and over again in this Subcommittee.

We've written letters to the Secretary of Defense. We'll continue to ask for DoD and NASA support. I would like to encourage the Department of Energy to pursue this support more aggressively.

I look forward to hearing from our distinguished witnesses today.

Mrs. **Lloyd**. Thank you, Mr. Morrison.

Mr. Fawell, do you have any remarks at this time?

Mr. **Fawell**. No, I do not. Thank you.

Mrs. **Lloyd**. Our first witness today is The Honorable Mary Ann Novak. She is Acting Assistant Secretary for Nuclear Energy at the Department of Energy.

This is the first appearance for Ms. Novak before the Committee and we do want to extend you a warm welcome. We want you to be at ease. Your entire statement will be made a part of the record and you may proceed as you wish.

STATEMENT OF MARY ANN NOVAK, ACTING ASSISTANT SECRETARY FOR NUCLEAR ENERGY, U.S. DEPARTMENT OF ENERGY, ACCOMPANIED BY JERRY D. GRIFFITH, ASSOCIATE DEPUTY ASSISTANT SECRETARY FOR REACTOR SYSTEMS DEVELOPMENT AND TECHNOLOGY

Ms. NOVAK. Thank you, Madam Chairman. I am pleased to have this opportunity to discuss with you the Department of Energy's programs and fiscal 1990 budget request for its Nuclear Energy Supply Research and Development activities. Accompanying me today are the Deputy Assistant Secretaries managing the programs we will be discussing.

I have submitted written testimony for the record to the Committee and would like now to summarize some of the various program activities.

Mrs. LLOYD. Please proceed as you wish.

Ms. NOVAK. As most of you know, nuclear energy plays a critical role in assuring the U.S. has a balanced, secure and stable energy supply. Some 20 percent of the electricity produced in the United States is now nuclear generated power.

Without nuclear power the U.S. would have used fossil fuels equivalent to approximately 2½ million barrels of oil per day and much of that of foreign origin. Revitalization of our nuclear option is the only alternative to an excessive reliance on fossil fuels and to generating electricity without producing carbon dioxide or sulphur emissions. It is also essential to the space and terrestrial missions that solar energy or other alternatives cannot now provide.

If our nuclear power industry is to produce power into the 21st century, many institutional and technical issues must be resolved.

One primary goal in reestablishing U.S. leadership in reactor designs is to permit use of a new generation of reactors with the designs that dispel many of the concerns we hear of today. These standardized reactors will need to be simpler in design and construction, employ passive safety features and be economically competitive. This will also increase U.S. export opportunities in the world energy market.

However, first the current nuclear regulatory process must be made to be more stable and predictable; not only to enhance safety but also to rationalize cost and construction schedules. Only through this process can a reasoned judgment on the benefits of nuclear power be realized. Financial risks involved with licensing alone are enough to prohibit nuclear power from becoming an economical option. Unless this issue is addressed by both the NRC and the Congress it is unlikely that any U.S. utility will order another nuclear power plant.

While these and other issues are formidable, the Department of Energy's fiscal 1990 budget request for Nuclear Energy Programs takes significant steps towards resolving them. The fiscal 1990 budget builds upon a solid foundation of strong support for long-term, high-risk research and development, balanced with cost-sharing where industrial partners stand to benefit commercially from federal investments in technology.

Of the overall budget request, $24 million is slated for the Light Water Reactor program. This is $2.8 million less than the fiscal 1989 appropriation. The Light Water program is a component of the Civilian Reactor Development Program which can lead to revitalization of the nuclear energy option in the early '90s. It provides a melding of an extensive worldwide operational experience base with the opportunity to incorporate major improvements such as the use of passive safety features, modular construction, and simplifications to improve reliability and availability. Because of this experience base, Advanced Light Water Reactors can be developed and deployed without the need for a demonstration plant.

For several years, U.S. utilities have been leading an extensive effort to establish a technical foundation for the design of the next generation of Light Water Reactors in the United States. The program is growing in national and international prominence and now involves participation on the part of several Far East and European utility companies.

The Department's Advanced Light Water Reactor program includes three key tasks: Support for the EPRI/industry program of defining technical requirements; demonstration of an improved standard plant licensing process needed for all advanced reactors by use of a certification of one or more advanced standard plant designs; and development and certification of a greatly simplified mid-size Advanced Light Water Reactor that employs predominantly passive safety features and modular construction.

The first task involves support for industry generation of the detailed requirements. Over 100 plants operating in the United States constitute an extraordinary experience base from which compelling conclusions can be drawn regarding both desirable and undesirable design features, and this is being used to develop an Advanced Light Water Reactor design which is an evolutionary improvement or refinement of the existing design base. Industry appropriately has the lead in this effort.

The second task of this program includes support for demonstration of an improved licensing process needed for all advanced reactors. This is being done through Nuclear Regulatory Commission certification of one or more large standard plant designs. That's over 1,000 megawatts to 1,350. Reactors being reviewed by the NRC include the General Electric Advanced Boiling Water Reactor, developed in collaboration with the Japanese, and the Combustion Engineering System 80+, which is an updated design building upon the Palo Verde plant in Arizona.

In the third area, design, development and certification activities are being supported for mid-size, approximately 600 megawatts, plant concepts. Designs are being developed which will take advantage of potential simplifications and innovations unique to the smaller power rating.

The 100 plus nuclear power plants now in commercial operation currently have an arbitrary license life of 40 years which is not based on technical restrictions. An additional 20 years of operating life, representing nearly 88,000 megawatts of capacity, is available and can directly and immediately offset some of the need for new or replacement generating units.

In order to preserve this resource, the criteria and technical basis for replacement, refurbishment, or continued use of components and systems as well as requirements to be used by the regulators for license extension reviews, must be developed and agreed on. This year support for two lead plants is being initiated on a cost-shared basis, with the objective of submitting the license for the lead renewals in 1991.

The Department of Energy's severe accident program is, of course, continuing to apply expertise gained from past severe accident technology programs, both at the NRC and the DOE, to the identification of potential design improvements.

On the Advanced Reactor Research and Development side, the Department is requesting $32.7 million. This is, as you pointed out, $43.3 million less than the fiscal 1989 appropriation. However, many of these funds were transferred to the facility lines to show a more accurate accounting on the facilities line, and the facility line dollars are still being spent to fully support the advanced reactor program development.

The Department's strategy is to support advanced reactor development on a cost-shared basis with the private sector, leading to a state where reference plant designs and the technology are completed for commercialization.

The advanced systems feature modular, factory fabricated, standardized designs enabling simplified licensing, lower construction costs, improved quality assurance, and greater flexibility for utilities to meet load growth.

Currently our program is centered around the Modular High Temperature Gas Reactor and the modular Liquid Metal Reactor. The High Temperature Gas Reactor offers the most comprehensive capability to passively and safely shut itself down under very severe upset conditions and is the only option for high temperature process heat applications. The $15 million provided by the government is not the full story, however. The civilian high temperature gas reactor has a high degree of commonality with the high temperature gas production reactor.

This New Production Reactor will benefit from as much as $57 million in research and design work in their fiscal '90 budget request under Defense Programs. Along with private sector and international cost sharing, we believe this considerably increases the work that can be accomplished for the high temperature gas reactor in the civilian market.

The Liquid Metal Reactor has the unique ability to recycle nuclear waste and thereby simplify waste disposal. It is the only reactor option which can extend uranium resources and it also has the capability to withstand severe upset conditions. General Electric's Power Reactor Inherently Safe Module (PRISM) is the design we are using as the reference liquid reactor plant. A three-year contract for advanced conceptual design with an optional two-year preliminary design phase is now in place. Interactions with the Nuclear Regulatory Commission are continuing and the results of ongoing reviews will be used to update design features. Again, the facilities and program budget augments this line item of $4 million.

Efforts on the metal fuel development program, commonly referred to as the Integral Fast Reactor program, will continue in 1990 to confirm the passive safety and improved economic potential of small sodium-cooled reactors using metallic fuel. International support is being developed to supplement the Department's funding of this program. $6.1 million is being requested in 1990 for this program activity.

On the facilities side, the Department's fiscal '90 budget request is $180 million, as you referred to. This is an increase of $42.3 million over last year's $137.7 million appropriation. Much of this, as I pointed out, is a transfer of funds from advanced reactors but we do reflect a $27.8 million increase in the facilities cost. That increase results from $21.8 million in uranium enrichment services, that is the SWU's that are necessary, and for safety and security improvements, that's $6 million. Our key facilities include the Experimental Breeder Reactor-II, the Fuel Manufacturing Facility, the Transient Reactor Test Facility, the Zero Power Physics Reactor, and the Hot Fuel Examination Facility at the Argonne National Laboratory West, near Idaho Falls; the Fast Flux Test Facility and the Fuels and Materials Examination Facility at the Westinghouse Hanford Company near Richland, Washington; and the comprehensive non-nuclear component test complex at the Energy Technology Engineering Center in California.

The Argonne National Laboratory West is the technology center for conducting the metal fuel development program, and reactor operations and metal fuel processing, fabrication, and waste treatment demonstrations to verify the closed metal fuel cycle.

The FFTF at Hanford is the newest and the largest research and development reactor in the Department's complex. Originally built to support the breeder reactor program, it is currently being utilized to perform fuel and material irradiation experiments for the Space and Defense Energy program, the Office of Energy Research Fusion program, and the Liquid Metal Reactor program and associated international agreements. In fiscal 1989, the Department is evaluating using FFTF as an alternative to using the Savannah River Plant to produce Pu-238.

At the Energy Technology Engineering Center, the primary effort is focused on sodium steam generator testing in support of a major cost-sharing international agreement with the Japanese Atomic Power Company.

During the past several years, the operational efficiency of these facilities has continuously improved through consolidation and broadened utilization. At the same time, nuclear facility safety management and oversight activities have been increased to further enhance the safety and protection of the public and the environment, to reflect the views of the National Academy of Sciences and the Department's Advisory Committee on Nuclear Facility Safety, and to initiate applicable Institute of Nuclear Power Operations good practices.

Since 1946 the Department's Isotopes Production and Distribution program has been the primary supplier of a large number of isotopes for domestic and foreign users in a variety of medical, industrial, agricultural, research and other applications.

The Department has recently made the decision that the management responsibility for the production and distribution of isotopes from DOE be assigned to the Office of Nuclear Energy. We are currently in the process of organizing that activity.

This program is essentially a business activity and we anticipate that the production and operating expenses associated will amount to $16.2 million. This amount will be offset by sales of these isotopes and related services amounting to $16.4 million. In fiscal 1990, we propose to establish a revolving fund that will provide for the costs associated with the production, sale and distribution of all DOE-supplied isotopes. This fund will permit the program to retain generated revenues which will then be used to continue ongoing operations and provide for other costs associated with the program.

The Space and Defense Power Systems program remains a vitally important element of the Department's Energy R&D effort. This program's primary mission is to develop nuclear energy power supply systems to respond to requirements identified by user agencies such as the National Aeronautics and Space Administration and the Department of Defense. The power systems and technologies developed in this area are intended to operate in remote and demanding environments, independent from logistical supply chains. Currently the emphasis in this program is on space power systems.

It is comprised of two main projects: the Spaced-Powered-100 space reactor in the range of tens to hundreds of kilowatts of electricity; and the Multimegawatt Space Reactor program which covers the range from tens to hundreds of megawatts of electric power.

The funding request for DOE's Space and Defense Power Systems program decreases by $21 million, as you noted, from $66 million in fiscal 1989 to $45 million in fiscal 1990. NASA and DOD will be providing additional funding to us totaling $51 million.

Radioisotope power sources for these civilian and military space and terrestrial missions have been in use for over two decades and are the cornerstone of the nation's space nuclear power program. The Advanced Nuclear Systems program provides base support for radioisotope fuel and heat source development, production and qualifications; nuclear safety analysis and testing; power converter system development; and all aspects of manufacturing, quality assurance, reliability and operational safety. This program includes construction activities at Hanford, Washington, in which future radioisotope power systems will be assembled and tested, replacing an older facility at the Mound Laboratory in Miamisburg, Ohio. This program also includes the Turbine Energy Conversion System project, formerly known as Dynamic Isotope Power System.

Current radioisotopes power projects include NASA's Galileo, which is scheduled for launch in October of this year and the Ulysses mission, currently scheduled for October 1990, as well as the upcoming Comet Rendezvous Asteroid Flyby and the Cassini Missions. The funding request for Advanced Nuclear Systems increases from $37.7 million in fiscal 1989 to $60.2 million in fiscal '90. This increase reflects the transfer of the costs of the Turbine Energy Conversion System and the Radioisotopes Power Systems Facility work to the Advanced Nuclear Systems program budget. NASA and DOE will also be providing an additional $7.3 million for this program.

The requested funds for the Remedial Action and Waste Technology program are distributed among the many program elements I have detailed in the written testimony. The fiscal 1990 request for this program is $238.6 million.

The major Remedial Action and Waste Technology activities include the Formerly Utilized Sites Remedial Action Project at sites formerly utilized by the Department's predecessor organizations or assigned by Congress; the Uranium Mill Tailings Remedial Action project for 24 inactive uranium mill tailings sites and several thousand associated vicinity properties; the Surplus Facilities Management Program for certain radioactively contaminated DOE facilities declared surplus and resulting principally from civilian nuclear energy programs; the West Valley Demonstration Project which will solidify high-level radioactive wastes at West Valley, New York for final disposal; the Low-Level Waste Program which provides technical assistance to the states and regions to assist them in developing new capacities for their low-level waste disposal, and the Byproducts Utilization Program, which DOE proposes to phase out in fiscal 1990.

Two of the more visible remedial action programs where significant progress has been made are the decommissioning of the Shippingport plant which began in 1985 and should be completed in early 1990, and the West Valley Demonstration Program. The reactor pressure vessel was removed from the Shippingport location on the barge yesterday afternoon and is currently enroute to the Hanford Reservation near Richland.

The West Valley Demonstration Project demonstrates the solidification of high-level nuclear wastes for transportation and disposal. An integrated production-scale development and demonstration project for treating approximately 600,000 gallons of high-level liquid nuclear waste is being carried out. Phase I, which includes the solidification project, will conclude in 1998.

Successful action of the Remedial Action and Waste Technology Program is a key part of the Department's overall commitment to continue to protect public health and safety and to assure a safe and clean environment in connection with all of its activities.

In conclusion, the Department would like to reiterate that nuclear energy is a key element required to provide America an adequate supply of energy at a reasonable cost. Based on conservative projections, we know there will be a need for new electrical generating capacity by the 1990s to replace old plants and to meet increased demand of our expanding population and economy.

Utilities should be able to consider building nuclear plants to meet a portion of this new capacity, yet the nuclear power option faces numerous interrelated technical, institutional and public perception problems that threaten its future use in the United States. At this critical point in its development, we must establish an effective and predictable regulatory and institutional environment; revitalize the Light Water Reactor option; develop advanced nuclear reactor systems with the potential for breakthroughs in economics, safety, licensability, and waste management; develop space nuclear energy power supply systems to meet the expanding needs of user agencies such as NASA and DOD; operate the isotopes and production program in a businesslike manner and continue remedial action programs to achieve progress in protecting the public health and safety and assuring a safe and clean environment.

Our fiscal 1990 budget takes further steps towards these goals, and with the help of this Committee we can ensure our progress in achieving them. Madam Chairman, this concludes my oral statement. As I mentioned earlier, I am accompanied by the managers of this program I have just outlined for you, who are ready to answer any questions the Committee may have.

[The prepared statement of Ms. Novak follows:]

STATEMENT OF

MARY ANN NOVAK

ACTING ASSISTANT SECRETARY FOR NUCLEAR ENERGY

BEFORE THE

HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

MARCH 1, 1989

Mr. Chairman, I am pleased to have this opportunity to discuss the Department of Energy's (DOE's) programs and fiscal 1990 budget request for its Nuclear Energy Supply Research and Development activities.

The requested funds are distributed among program elements summarized in the following tables.

Budget Authority

($ in Millions)

Program Element	FY 1989 Appropriation	FY 1990 Request
Energy Supply R&D		
Nuclear Energy R&D	352.7	350.7
Remedial Action and Waste Technology	254.7	238.6
Policy and Management	2.2	2.2
Total	609.6	591.5

Budget Outlays

($ in Millions)

Program Element	FY 1989 Appropriation	FY 1990 Request
Energy Supply R&D		
Nuclear Energy R&D	352.7	350.7
Remedial Action and Waste Technology	263.1	246.6
Policy and Management	2.2	2.2
Total	$618.0	$599.5

Detailed funding tables are included in the discussion of each major program.

OVERVIEW

Nuclear energy plays a critical role in assuring a balanced, secure, and stable energy supply for America's electrical power needs and space nuclear power applications. During the first three quarters of 1988, approximately 20% of electricity produced in the United States came from nuclear power.

Without nuclear power, the U.S. would have used fossil fuels equivalent to approximately two and one half million barrels of oil per day. As a complementary benefit, this electricity was generated without producing carbon dioxide or sulfur emissions which contribute to global warming and acid rain. Timely revitalization of the nuclear option for the United States is the only realistic alternative to a potentially excessive reliance on coal or other fossil fuels, and remains essential to our nuclear power research program for certain planned space and terrestrial missions that solar energy or alternatives cannot provide.

In order for the Nation's nuclear power industry, including utilities, plant designers and constructors, to be capable of providing power into the next century, institutional and technical issues must be resolved. One institutional hurdle was successfully cleared when the 100th Congress renewed the Price-Anderson Act, providing a 15-year extension of insurance and contractor indemnity coverage that can be relied upon in the unlikely event of a major nuclear accident. But other issues still require resolution.

The current nuclear regulatory process needs to be made more stable and predictable in order to enhance safety, rationalize cost and construction schedules and allow a reasoned judgment on the benefits of nuclear-generated electricity. The financial risks involved with the licensing process alone are enough to bar nuclear power as an economical option. Unless the nuclear plant licensing process is substantially changed, it is unlikely that any U.S. utility will order another nuclear plant.

A primary goal of the DOE program is to permit use in the United States of a new generation of reactors with designs that dispel many of the concerns facing the industry today and at the same time increase export opportunities for U.S. reactors in the world market. These new standardized reactors will be simpler in design and construction; employ passive safety features; and be economically competitive.

While these and other issues confronting the expanded use of nuclear power are formidable, the Department of Energy's FY 1990 budget request for Nuclear Energy programs takes significant steps toward resolving them.

In FY 1990, the Nuclear Energy R&D program will continue the diverse activities initiated over the past years to address technology issues related to safe, economical and reliable reactors and space and terrestrial power systems. Our efforts in the light-water reactor program will focus on demonstrating the important reactor standardization process by obtaining the Nuclear Regulatory Commission (NRC) certification of a process through certifying an improved light-water reactor and continuing development and certification of advanced light-water reactors (ALWR) employing passive safety features and modular construction. In addition, the modular high-temperature gas reactor (MHTGR) and the liquid metal reactor (LMR) will continue licensing interactions with the NRC on design activities and supporting Technology R&D with the ultimate goal of obtaining NRC design certification. We will also continue development and demonstration of the Integral Fast Reactor (IFR) concept to confirm passive safety and economic benefits. Cost-sharing arrangements and new international cooperative agreements will also be pursued to expand our technology base and defray development and operating costs.

Our efforts in the area of space nuclear power in FY 1990 will culminate in the delivery of nuclear power sources for use on NASA's deep space probes, Galileo and Ulysses, scheduled for launch in October 1989 and October 1990 respectively. The SP-100 test site reactor design will be completed along with the Safety Analysis Report. A reliable, long-term supply of Plutonium-238 is needed for radioisotope power supplies and we are evaluating the use of the Fast Flux Test Facility (FFTF) in Washington State or the Savannah River Plant in South Carolina to satisfy this requirement.

The Remedial Actions program continues to provide evidence of our skills and technology to safely dispose of retired reactor sites and handle wastes. A notable accomplishment under this program is the Shippingport decontamination and decommissioning effort which will be completed in FY 1990. Work will also proceed in the areas of high-level waste solidification and low-level waste management. Other projects under the Formerly Utilized Sites Remedial Action Project, the Uranium Mill Tailings Remedial Action Project, and the surplus facilities program will continue.

I believe the programs proposed by the Office of Nuclear Energy for fiscal year 1990 will support the continuation and development of safe and economical nuclear power sources as an essential ingredient in our Nation's mix of safe and abundant energy sources.

More detailed discussion of the scope, status and budget request for all programs is contained in the sections that follow.

NUCLEAR ENERGY RESEARCH AND DEVELOPMENT

The funding request for Nuclear Energy R&D programs is contained in the following table.

Budget Authority

($ in Millions)

Program Element	FY 1989 Appropriation	FY 1990 Request
Nuclear Energy R&D		
Light Water Reactors	26.8	24.0
Advanced Reactor R&D	76.0	32.7
Facilities	137.7	180.0
Space/Defense Power Systems	66.0	45.0
Advanced Nuclear Systems	37.7	60.2
Program Direction	8.5	8.8
Total	$352.7	$350.7

LIGHT WATER REACTORS

The Nation's economic and national security requires a diversified energy supply base built upon adequate domestic resources that are relatively free from international pressures. Nuclear energy is a safe, economically competitive, and environmentally acceptable option and is a vital component of the national energy supply to meet current and future national energy demands.

The Light Water Reactor (LWR) program is the component of the Civilian Reactor Development Program which can lead to the revitalization of the nuclear energy option in the early 1990s. It provides a melding of an extensive worldwide operational experience base with the opportunity to incorporate major improvements, such as the use of passive safety features, modular construction, and simplifications to improve reliability and availability. Because of the LWR experience base, improved Advanced Light Water Reactors (ALWRs) can be developed and deployed without the need for a demonstration plant.

The objectives of DOE's LWR program are to cooperate with the industry to:

- provide an effective and predictable regulatory and institutional environment that enables nuclear power projects to compete freely in the marketplace;
- support and facilitate industry-led technology efforts to revitalize the LWR option for the United States and to ensure its long-term availability as a vital component of the national energy supply system;
- ensure that the national resource of more than 100 operating LWRs is not prematurely lost due to arbitrary licensing periods.

The ALWR program is the major focus of the LWR program and supports activities to develop and obtain utility and Nuclear Regulatory Commission (NRC) certification of ALWRs and to demonstrate the improved regulatory processes needed for all advanced reactors. The second part of the LWR program--Current and Advanced Light Water Reactor Safety and Licensing Support--provides technology support to the ALWR program and will be discussed later.

ADVANCED LIGHT WATER REACTOR PROGRAM

For several years, U.S. utilities have been leading an extensive industry-wide effort to establish a technical foundation for the design of the next generation of light water reactors in the United States. The program is growing in national and international prominence and now involves participation of several Far East and European utility companies.

Three fundamental standards must be met before the ALWR can be considered a viable candidate for U.S. utility investment. First, it must be an excellent powerplant in all respects. Safety is the foremost concern, but it must also embrace all of the criteria by which powerplants are measured, including reliability, maintainability, and compatibility with the environment. Secondly, it must be economically attractive in comparison to alternative fossil-fired units. Finally, and of particular importance for nuclear plants, the ALWR must provide very high protection of utility investment, in terms of predictable construction costs and schedule, assured licensability, predictable operating and maintenance costs, and very low risk of severe accident.

The Department's ALWR program includes three key tasks:

- support for the EPRI/industry program of defining technical requirements for ALWRs;
- demonstration of the improved standard plant licensing process needed for all advanced reactors by certification of one or more ALWR standard plant designs; and,
- support industry in the development and certification of greatly simplified mid-sized (about 600 MWe) LWRs that employ predominantly passive safety features and modular construction.

The first task involves support for industry generation of detailed requirements for future ALWRs. Over 100 operating nuclear plants in the United States constitute an extraordinary experience base from which compelling conclusions can be drawn regarding both desirable and undesirable design features. Notwithstanding plant-to-plant variations, the overall performance of U.S. nuclear plants has been good. Specific regulatory guidelines, plant operator training methods, and specific hardware designs have evolved based on these existing reactor systems. For all these reasons, a logical and high-success approach for the ALWR Program is to examine carefully this existing technical basis and to develop an ALWR design which is an evolutionary improvement or refinement of the existing design base. Industry appropriately has the lead in this effort.

The second task of the ALWR Program includes support for demonstration of the improved licensing process needed for all advanced reactors through NRC certification of one or more large (1,250 to 1,350 MWe) standard plant designs. Reactors being reviewed by NRC include the General Electric (GE) Advanced Boiling Water Reactor (ABWR) design, developed in collaboration with the Japanese, and the Combustion Engineering (CE) "System 80+" Advanced Pressurized Water Reactor (APWR) design, using the "System 80" Palo Verde design as its basis. Good progress was made last year in establishing the NRC review process, coordinating with the EPRI/utility industry requirements and criteria, and in submitting the initial chapters of the Standard Safety Analysis Reports (SSARs) to the NRC for review. These SSAR submittals, and related safety analyses, will be completed during 1989. In FY 1990, additional required risk assessments and safety evaluations will be prepared, and revisions to the safety reports and evaluations as needed to resolve NRC comments will be submitted. Final design approval by 1990 is expected. Based on favorable review, the ABWR design is expected to be certified by the NRC in late 1991. Due to recently-imposed NRC requirements and funding priorities, the System 80+ may not be certified, but may be redirected to an intermediate objective.

In the third task area, DOE supports design, development, and certification activities on a cost-shared basis for mid-size passive (600 MWe) plant concepts. These plants offer the opportunity to incorporate further, highly desirable, evolutionary changes to LWRs. Designs are being developed which will not only build on the extensive experience base from the last three decades of LWR reactor operation, but will also take advantage of potential simplifications and innovations in design and construction that are unique to the smaller power rating. These include the application of more-passive systems and the increased use of modularization to improve construction.

The ALWR passive plant employs primarily passive means (such as gravity or natural circulation) to remove decay heat and provide emergency core cooling to prevent core damage, as well as to contain fission product activity even in the unlikely event of a core damaging accident.

The coordinated DOE/industry program on passive plants will result in availability of certified plant designs by 1995.

SAFETY AND LICENSING SUPPORT OF CURRENT AND ADVANCED LWR'S

This program deals with plant lifetime extension, severe accidents, and institutional matters supporting not only ALWRs but also bearing significantly on extension and preservation of the current national energy resource represented by today's LWRs.

The 100-plus nuclear powerplants now in commercial operation are a large untapped resource of future energy when one considers that their current license life of 40 years is not based on technical restrictions. An additional 20 years of operating life, representing nearly 88,000 megawatts of capacity, is potentially available and can directly offset some of the need for ~~new or~~ replacement generating units. In order to preserve this resource, the criteria and technical bases for replacement, refurbishment, or continued use of components and systems, as well as the procedural requirements to be used by regulators for license extension reviews, must be developed and agreed upon. In FY 1988, the development of the technical base for one of the key components, the reactor containment, was pursued. Questions regarding electrical cable and reactor vessel life were also addressed. In FY 1989, support for two lead plants is being initiated on a cost-shared basis, with the objective of submitting the applications for the lead license renewals in 1991.

The DOE severe accident program is applying expertise gained from past severe accident technology programs to the identification of potential design improvements for future plants. In cooperation with the utility ALWR Steering Committee, the DOE program has contributed to safety requirements and supporting bases for the Utility Requirements Document. The key chapter on safety and severe accidents in this document has been submitted to NRC and interactions with NRC were initiated during FY 1988. In FY 1989, discussions with the NRC on the acceptability of these requirements will be completed. The program is also supporting the ALWR certification program by providing recommendations for closing severe accident issues for the ALWR. Interactions with the NRC staff on these severe accident issues will take place during during FY 1989, with final resolution and regulatory criteria documented in FY 1990. Also in FY 1990, analysis of severe accident issues and support to the Requirements Document associated with passive plants will occur.

THREE MILE ISLAND

No additional funding for Three Mile Island (TMI) activities is being requested in FY 1990 because DOE will complete its R&D program with funds appropriated for FY 1988.

The GPU Nuclear Corporation (GPU Nuclear) expects to complete defueling of the core debris in 1989 with completion of debris shipments in 1990. GPU Nuclear also expects to complete the recovery program and place the plant in a safe, monitored condition during 1990.

During FY 1989, a final revised accident scenario incorporating the results from the Committee for the Safety of Nuclear Installations program will be prepared. This will include the observations made during the lower vessel defueling and DOE sample examinations.

ADVANCED REACTOR R&D

For FY 1990, the Department is requesting $212.7 million for advanced reactor research and development and nuclear energy facilities support. Advanced reactor systems offer the potential for significant improvements in safety, economics, licensability, and waste management and could be available in the late 1990's and early next century. The Department's strategy is to support advanced reactor development on a cost shared basis with the private sector leading to a state where reference plant designs and the technology are completed for commercialization.

The Department's advanced reactor program is centered around the modular High Temperature Gas Reactor and the modular Liquid Metal Reactor:

- The High Temperature Gas Reactor (HTGR) offers the most comprehensive capability to passively and safely shut itself down under very severe upset conditions and is the only option for high temperature process heat applications.

- The Liquid Metal Reactor (LMR) has the unique ability to recycle nuclear waste and thereby simplify waste disposal, is the only reactor option which can extend uranium resources, and also has the capability to withstand severe upset conditions.

The advanced reactor systems feature modular, factory fabricated, standardized designs which enable simplified licensing; lower construction costs; improved quality assurance; and greater flexibility for utilities to meet load growth. International cooperation is integral to the advanced reactor program. Joint U.S. and foreign funding of R&D at U.S. facilities, such as experiments conducted at the Fast Flux Test Facility (FFTF) and at Experimental Breeder Reactor-II (EBR-II) for Japan, minimizes advance reactor program costs and supports completion of required R&D.

Advanced Liquid Metal Reactor

The FY 1990 advanced reactor R&D budget request includes $17.7 million for liquid metal reactor program activities. Key advanced LMR activities are to: complete the Integral Fast Reactor (IFR) demonstration program;

complete development of the reference plant design; and test major components and key features in Nuclear Energy test facilities.

During FY 1990, IFR program efforts at Argonne National Laboratory (ANL) will continue to confirm the passive safety and improved economic potential of small sodium cooled reactors using metallic fuel with optional on-site fuel reprocessing. International support is being developed to supplement the Department's funding of the IFR program. It is planned to start hot operations of the Hot Fuel Examination Facility-South for the IFR fuel recycle demonstration by the end of FY 1990.

ANL, General Electric, and other advanced reactor program contractors will evaluate the capability of the LMR to recycle fuel and destroy the long-lived actinide elements (plutonium, neptunium, and others) present in spent LWR, LMR and HTGR fuel. LMR actinide burning has the potential to reduce the volume of waste material sent for permanent underground storage and reduce the biological risk of high-level waste from hundred's of thousands of years to hundred's of years.

General Electric's PRISM design is the reference LMR plant. A three-year contract for advanced conceptual design with an optional two-year preliminary design phase is in place for development of the concept. Interactions with NRC will continue and the results of ongoing reviews will be used to update design features and to resolve key issues defined by the NRC in the forthcoming Safety Evaluation Report and licensability letter.

Facilities testing of major components and key features will focus on establishing the performance characteristics of advanced steam generators and advanced fuels and materials. Such testing provides the technical basis for major regulatory reform through demonstration of passive safety features and design capability.

International cooperative R&D efforts will continue in the areas of LMR oxide fuel cycle, shielding experiments and in the collection of reliability and failure data from existing LMR's (FFTF, EBR-II, JOYO). DOE will also complete convertibility studies and analyses and technology transfer to support conversion of foreign test reactors to low enriched uranium fuel.

Modular High Temperature Gas Reactor (MHTGR)

The FY 1990 advanced reactor R&D budget request includes $15.0 million for the MHTGR program. The following activities will be emphasized: multi-module controls; passive reactor cavity cooling systems; fuel fabrication; irradiation testing; and licensing interactions with the NRC. International cooperative R&D efforts will continue under existing agreements with Japan, Germany, France, Switzerland and the United Kingdom.

Additional funding provided by private sector/foreign sources as part of a proposed cost sharing initiative would be used to further emphasize preliminary design and licensing activities in support of current plans for submittal of a Preliminary Standard Safety Analysis Report to the NRC in 1992.

The MHTGR is one of the reactor technologies being assessed for New Production Reactor development. A plan to coordinate and integrate commercial and defense R&D programs is being developed.

FACILITIES

The Nuclear Energy (NE) facilities provide safe, reliable, and economical testing capabilities essential for the development and verification of nuclear power systems for civilian applications and space and defense power systems. The key facilities include the Experimental Breeder Reactor-II (EBR-II), the Fuel Manufacturing Facility (FMF), the Transient Reactor Test Facility (TREAT), the Zero Power Physics Reactor (ZPPR), and the Hot Fuel Examination Facility (HFEF), at the Argonne National Laboratory-West (ANL-W) near Idaho Falls, Idaho; the Fast Flux Test Facility (FFTF) and the Fuels and Materials Examination Facility (FMEF) at the Westinghouse Hanford Company (WHC), near Richland, Washington; and the comprehensive non-nuclear component test complex at the Energy Technology Engineering Center (ETEC) near Canoga Park, California.

During the past several years, the operational efficiency of NE's facilities has continuously improved and non-essential facilities have been shut down, resulting in improved productivity. Nuclear facility safety management and oversight activities were increased in FY 1988 to further enhance safety and protection of the public and the environment, to reflect the reviews by the National Academy of Sciences (NAS) and the Department's Advisory Committee for Nuclear Facility Safety (ACNFS), and to initiate applicable Institute of Nuclear Power Operations (INPO) good practices. As part of NE's effort to improve the cost-effectiveness of facilities operations, the privately-financed electric generation system at ETEC began operation in FY 1988.

ANL-W is the technology center for conducting the metal fuel development program, and reactor operations and metal fuel processing, fabrication, and waste treatment demonstrations to verify the closed metal fuel cycle. During FY 1990, activities include advanced safety testing in EBR-II, and completing modification and starting facility checkout operations for metal fuel processing systems in HFEF-South.

FFTF is the newest and largest research and development reactor in the Department's facility complex. Originally built to support the breeder reactor program, it is currently being utilized to perform fuel and material irradiation experiments for the space and defense energy program, the fusion program, and the liquid metal reactor program and associated international agreements. In FY-1989, the Department will evaluate using FFTF as an alternative to the Savannah River Reactors to produce Pu-238. This isotope is used in Radioisotope Thermal Generators (RTG's), an essential power source for NASA and DOD missions. Upon completion of the evaluation and a decision by the Department, FFTF will continue to operate or be shutdown consistent with firm plans to be developed regarding the future utilization of this facility.

ETEC focuses on non-nuclear testing of components with emphasis on sodium steam generator performance and endurance testing at the Sodium Component Test Installation. More than one-half of the support for ETEC operations is currently being derived from international cooperative programs, private industry (including revenues from private utilities for electrical generation on the ETEC site), and from other sources outside the Nuclear Energy R&D budget. In FY 1990, an attempt will be made to obtain additional cost sharing from international and private industry that would match Nuclear Energy R&D Facilities funding at ETEC. If successful, steam generator testing will be conducted, as described above; if unsuccessful, ETEC will be placed in standby.

Other facility activities include completing shipment of spent fuel pins and pin segments from the Los Alamos National Laboratory (LANL) to the Pacific Northwest Laboratory for long-term storage, and transfer of responsibility of the LANL Wing-9 Hot Cell to the Surplus Facilities Management Program for future decontamination and decommissioning. Studies, evaluations, and management support activities will be continued as needed. Further, actions will continue in response to the recommendations from the NAS review of Category A reactors, including FFTF and EBR-II.

ISOTOPES PRODUCTION AND DISTRIBUTION

Since 1946, the Department of Energy (DOE) and its predecessor agencies have been the primary supplier of a large number of isotopes for domestic and foreign users in a variety of medical, industrial, agricultural, research, and other applications. These isotopes are produced in a number of DOE facilities using funds from several different DOE accounts. Due to the importance of these isotopes to our society we reviewed the program and concluded that the Isotope Production and Distribution activity should be consolidated under a single Headquarters program and not involve funding from several different DOE accounts. Following that review, the Department has recently made the decision that the management responsibility for the production and distribution of isotopes from DOE be assigned to the Office of Nuclear Energy. We have already identified several issues for review and by July, 1989, we will initiate corrective actions on creation of a plan for program consolidation, including guidance for funding and staffing resources; establishment of a DOE-wide isotope pricing policy that provides full cost recovery; and development of a total program budget, including plant, equipment, and environment, safety, and health requirements.

The funds requested in FY 1990 for this activity are identified in the following table:

($ in Millions)

FUNDING ACTIVITY

	FY 1988	FY 1989	FY 1990
Isotope Production	17.3	16.2	16.2
Receipts from Isotope Sales	17.4	16.4	16.4

In Fiscal 1990, the Isotope Production and Distribution Program will continue to provide radioactive and stable isotope products and associated services to a wide and varied domestic and international market. We anticipate that the production and operating expenses associated with this program will amount to $16.2 million dollars, which will be offset by receipts from the sales of these isotopes and related services amounting to $16.4 million. This program is essentially a business, and we think it should be conducted as one. Therefore, in FY 1990, we propose to establish a revolving fund that will provide for the incremental costs associated with the production, sale, and distribution of all DOE-supplied isotopes.

This fund will permit the program to retain revenues generated by the fund, which will then be used to continue ongoing operations and provide for other incremental costs associated with the operation and maintenance of the facilities used by this program. The effect of these efforts will be to assure, through clearly delineated management channels and budget controls, the continuation of the benefits gained from the use of nuclear isotopes.

SPACE AND DEFENSE POWER SYSTEMS

The Space and Defense Power Systems program remains a vitally important element of the Department's nuclear energy R&D effort. The program's primary mission is to develop nuclear energy power supply systems to respond to requirements identified by user agencies, such as the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD). Program activities over the years have included the design, development, fabrication and testing of compact, high performance reactors for space and terrestrial applications. In general, these power systems and the technologies developed in this program are intended to operate in remote and demanding environments, independent from logistical supply chains. In many cases, they represent the only power sources capable of fully meeting user mission requirements. Currently, the emphasis is on space power systems. The program is comprised of two main projects - the SP-100 space reactor in the range of tens to hundreds of kilowatts electric; and the Multimegawatt (MMW) Space Reactor program, which covers the range from ten to hundreds of megawatts electric.

The Department has undertaken these nuclear energy projects to meet expanding space and defense power requirements as part of its overall nuclear development charter under the Atomic Energy Act to support other Federal agencies as well as civilian energy needs.

In addition to the funding provided by DOE, these projects are also supported by NASA and/or DOD. In one instance, the MMW Space Reactor project, only DOD will provide funds in FY 1990, but DOE will continue to manage the program in support of DOD.

DOE's space reactor projects build on the technologies developed as part of the Department's civilian power reactor programs, primarily the liquid metal and gas-cooled reactor programs. As in past years, it is anticipated that eventually there will be meaningful feedback to the commercial reactor programs from accomplishments of the space power programs, particularly in the areas of fuels, materials and reactor control systems.

The funding request for DOE's Space and Defense Power Systems program decreases by $21 million, from $66 million in FY 1989 to $45 million in FY 1990. NASA and DOD will be providing additional funding. The Dynamic Isotope Power System (DIPS), which was included in this category last year, has been moved to the Advanced Nuclear Systems (ANS) program and is now called the Turbine Energy Conversion System (TECS). Also transferred to the ANS activity is the Radioisotope Power Systems Facility at Hanford, Washington. This change places all radioisotope power systems oriented activities in the ANS program and all reactor power systems activities in the Space and Defense program category.

SP-100 Space Reactor

The objective of the SP-100 project is to develop, demonstrate, and make available to the user community space nuclear reactor technology in the tens to hundreds of kilowatts-electric range. The SP-100 is in the third year of engineering and design of its ground test reactor, with nuclear fuel, materials and component tests underway. During the past year the program has completed major system design activities and manufactured almost one-half of the nuclear fuel for the ground test reactor. The project is presently proceeding with procurement, fabrication, testing and demonstration of prototypic system components.

The SP-100 project began in 1983 with the initiation of technology assessment. In 1985, this first phase of the program was completed when a fast spectrum, liquid metal-cooled reactor concept utilizing thermoelectric power conversion was selected by DOD, NASA, and DOE for development and testing. Also, in 1985, the Westinghouse Hanford Company (WHC) was selected as the preferred site for the ground demonstration test of the nuclear reactor. In late 1986, an industrial team, led by General Electric (GE), was awarded the SP-100 system development contract. In 1987, the SP-100 planned test power level was reduced from 300 to 100 kilowatts-electric to reflect a change in user requirements and the program extended a year due to funding shortfalls.

Even with restructuring over the past 18 months, substantial progress has been made, including completion of the Generic System design. In addition, the General Electric team working with the Westinghouse Hanford Company has continued to define the detailed design requirements for the Nuclear

Assembly Test, during which the SP-100 reactor system will be tested in a vacuum chamber. Many of the key technology issues have been resolved through design and testing, with monitoring equipment at the Fast Flux Test Facility showing good results from the on-going high temperature materials tests. Progress in hardware production, fabrication, and performance in many of the primary components has been achieved.

In FY 1989, major accomplishments will include assembly of the initial thermoelectric cells, the essential building block of the power conversion system. Hardware currently on test will continue to provide essential lifetime data. Lifetime testing will be continued for fuel and material irradiation, heat pipes, and material coatings. Component level testing will be completed on key hardware, including the pump, heat pipe radiator, and control drives.

We will continue fabricating fuel for the reactor ground test and the fuel pin assembly will be initiated. The definitive design of the site facility modifications will also proceed, with safety analysis being performed to support the ground reactor test. Work will continue on the test site reactor design, the Preliminary Safety Analysis Report (PSAR), procurement of the vacuum vessel and facility modifications. The public review of the test site Environmental Assessment will be completed.

Key technology development activities will continue at the supporting national laboratories. The system contractor will continue with the design, analysis, development, and testing of system components. Preliminary studies for the SP-100 Flight Experiment have been initiated by the DOD. This effort is being coordinated with DOE and NASA. Work on the

Flight Experiment will continue through FY 1989. Primary emphasis in the SP-100 program will be on the continued development, fabrication, and testing of system hardware.

In FY 1990, assembly of the initial thermoelectric cells and modules for lifetime testing will continue, as will lifetime irradiation testing of fuel and materials. The fabrication of fuel pellets for the nuclear assembly test will be completed and the bonded fuel cladding will be fabricated and delivered for fuel pin assembly.

Activities at the ground reactor test site in FY 1990 will include initiation of the vacuum vessel fabrication, completion of the test site reactor design and Final Safety Analysis Report (FSAR). Construction modification of the test facility will continue.

Multimegawatt (MMW) Space Nuclear Power

In late 1985 a second reactor development effort, the MMW Space Nuclear Power program was initiated as a joint DOD/DOE program to meet the Strategic Defense Initiative (SDI) power needs beyond those provided by SP-100. The program currently contains two subprograms, the MMW Space Reactor program and the Thermionic Fuel Element Verification (TFE) program. In addition to supporting SDI needs, the MMW program could provide NASA far-term civilian space reactor power systems for advanced MMW powered propulsion units for interplanetary travel and exploration, advanced lunar and planetary settlements, and energy-intensive space industrial plants.

Preliminary assessments of 20 different MMW space reactor concepts were completed in 1987. In 1988, contracts were awarded to conduct Phase I concept assessments and technology feasibility evaluations of 6 different MMW space reactor concepts. In January of this year, Phase II proposals were submitted for evaluation and selection of up to a maximum of 3 of the Phase I concepts for further Phase II contractor activities. The Phase II completion date will be extended to the mid 1990's.

Supporting technology development activities have been conducted at the national laboratories with three of the more important MMW technology accomplishments being the fabrication and start of in-core testing of two fueled particle bed reactor fuel elements; initial fabrication and demonstration of an advanced, lightweight, stowable heat pipe reactor, and the fabrication of high temperature, thin-walled refractory tubing. While no supporting laboratory technology development activities are planned for FY 1990, DOE will continue to manage the concept development activities for DOD, which will provide the required funding.

Thermionic Fuel Element (TFE)

The TFE portion of the MMW Space Nuclear Power program was established to resolve outstanding issues associated with the use of thermionic fuel elements in space reactor systems operating in the low megawatt continuous power range. It is essentially a component development effort aimed at demonstrating seven to ten year operational lifetimes of TFE components through accelerated and real time testing in appropriate radiation environments.

The development effort includes a series of tests involving insulators, fueled emitters, collectors, and single cell thermionic converters. The tests are being run primarily in the EBR-II and FFTF facilities. The program will culminate with a prototype test of a thermionic fuel element in FFTF in FY 1993.

ADVANCED NUCLEAR SYSTEMS

The Advanced Nuclear Systems (ANS) program produces radioisotope power sources for U.S. civilian and military space and terrestrial missions. Radioisotope power sources have been in use for over two decades and are the cornerstone of the Nation's space nuclear power program. The ANS program provides base support for radioisotope fuel and heat source development, production and qualification; nuclear safety analysis and testing; power converter system development; and all aspects of manufacturing, quality assurance, reliability, and operational safety for radioisotope power systems. The program includes construction of the Radioisotope Power Systems Facility (RPSF) at Hanford, Washington, in which future radioisotope power systems will be assembled and tested in a modern facility meeting all safety and environmental requirements. The RPSF will replace an older facility at the Mound Laboratory in Miamisburg, Ohio. The ANS program also includes the Turbine Energy Conversion System (TECS) project.

Current radioisotope power projects within the ANS program include NASA's Galileo, Ulysses, Comet Rendezvous Asteroid Flyby (CRAF), and Cassini missions as well as DOD's special terrestrial applications. Most of these projects are jointly funded with DOD or NASA. The funding request for

Advanced Nuclear Systems activities increases from $37.7 million in FY 1989 to $60.2 million in FY 1990. This increase reflects the transfer of the costs of the TECS and RPSF work to the ANS program budget.

Radioisotope Thermoelectric Generators

In FY 1989 and 1990, DOE intends to commit resources to the production of Plutonium (Pu)-238 fuel and initiate manufacturing operations of iridium heat source modules and carbon insulator assemblies for fabrication of radioisotope thermoelectric generator (RTG) fuel capsules for future missions. In FY 1990, the selection process will be completed and an award made for a systems contractor for the CRAF and Cassini flight programs. Pu-238 fuel fabrication and Neptunium (NP-) 237 target fabrication facilities are being made operational. These efforts will continue and be increased. Actual production of Np-237 targets needs to commence by early 1990 and continue in the outyears to support production schedules for NASA and DOD projects. The issues of a reliable source of Pu-238 and fuel cost reimbursements from NASA and others needs to be resolved and reflected in FY 1990 and outyear budgets.

The environmental, safety and operational uncertainties of the aging Savannah River facilities have raised concerns both within the Department and with NASA and DOD program managers over the U.S.'s capability to provide the material required for vital user agency missions. The use of the Fast Flux Test Facility and the Fuels and Material Examination Facility (FFTF/FMEF) at Hanford, Washington, to produce Pu-238 is being evaluated along with the use of the production facilities at the Savannah River Plant.

The delay in the launch of Galileo to October 1989, and Ulysses to October 1990, added appreciably to DOE's activities, particularly in RTG safety and testing as well as in the launch support area. Since the January 1986 Challenger accident, DOE has been working closely with NASA to prepare an updated FSAR for Galileo as a result of new launch requirements. The FSAR was completed and issued in January 1989. Modeling and extensive impact testing, especially with solid rocket motor fragments, reconfirmed the safety and reliability of the General Purpose Heat Source (GPHS) design and power supply for the Galileo and Ulysses launch configurations. The Interagency Nuclear Safety Review Panel composed of NASA, DOD and DOE is currently conducting an independent analysis of the FSAR and other information to support the decision process to launch the Galileo spacecraft. DOE is supporting these efforts. Similar launch support and safety analyses and reviews will be required in FY 1989 and 1990 for the Ulysses mission.

In FY 1989 the Galileo radioisotope units will be shipped to the Kennedy Space Center and mated with the spacecraft. In FY 1990 similar activities will be required for the Ulysses spacecraft. DOE will continue to conduct long-term performance tests (life tests) on the qualification unit to confirm reliability and power predictions for the Galileo and Ulysses missions while they are in transit to Jupiter and the Sun, respectively. The backup Ulysses flight RTG will be returned to the Mound Facility in 1990 for monitored storage until it is required for the CRAF mission in 1995. The CRAF and Cassini missions require a total of 5 RTGs including the existing backup RTG.

DOE is continuing to pursue the technology and the development of an advanced modular RTG that offers the promise of higher power density and greater size adaptability for a wide range of DOD and NASA missions on a more cost-effective basis. During 1989 and 1990, thermoelectric modules will be produced and assembled into a ground demonstration system (GDS) for engineering tests. In FY 1990, the GDS assembly and performance tests will be completed and life testing activities initiated. Associated multicouple life prediction models will be completed and a flight program reliability test matrix will be initiated.

Efforts will continue in FY 1990 to improve heat source and converter performance and safety, improve production efficiencies to reduce costs, and pursue long-lead development areas, especially in the thermoelectric materials area. To assure safe transport, the design of a state-of-the-art RTG shipping container will be completed and fabrication will be initiated.

Radioisotope Power Systems Facility

In FY 1989, DOE began the detailed design of construction modifications to the Fuels and Materials Examination Facility (FMEF) at the Hanford, Washington site to provide a Radioisotope Power Systems Facility (RPSF) that meets all safety, environmental, security, safeguards, and seismic requirements for nuclear facilities. The RPSF will provide a modern, efficient production line for the assembly, fueling and testing of RTGs required in the 1990's and beyond. Moreover, it will have the capacity to handle larger and multiple power supplies, which currently does not exist. In FY 1990 the detailed design will be completed and construction modifications will be initiated along with procurement of long lead items.

Completion of the RPSF is scheduled for 1992. Coupling the RPSF with a FFTF/FMEF plutonium fuel production capability would provide a fully integrated and cost-effective RTG production capability at a single location. Funding for the FFTF/FMEF production mission is not included in this budget request, pending a final determination on the plutonium-238 supply approach to be taken.

Special Applications

To meet DOE obligations to deliver RTGs for terrestrial national defense missions, the Special Applications program will continue its efforts to develop and demonstrate the necessary technology and to produce devices that meet user requirements. During FY 1989, DOE will continue design and integration studies for specific missions, reliability testing, provide refurbishment and production services and complete tooling requirements for modifications at the Mound Facility to support the fueling, assembly, testing, and delivery of a 180-watt RTG in FY 1990. In FY 1990, a 2-watt prototype RTG will be produced and begin long-term reliability tests and production will commence to meet delivery requirements. DOE will also continue ongoing production and refurbishment activities, and initiate the safety qualification of a new, small terrestrial unit.

Turbine Energy Conversion System

The Turbine Energy Conversion System program, formerly entitled the Dynamic Isotope Power Systems (DIPS), is developing the next generation of isotope power systems using dynamic conversion technology. TECS is the preferred approach to meeting evolving NASA and DOD space and terrestrial power requirements in the one to ten kilowatt electric range. It has the capability to convert heat to electricity several times more efficiently than current RTGs, thereby permitting more cost-effective use of radioisotope (Pu-238) supplies.

The program will address all key technological issues through the design, fabrication, and testing of electrically heated engineering and qualification units, including a full scale system demonstration test of the turbine-alternator system. The Department has selected Rockwell International as its lead contractor.

In FY 1990, the program will emphasize the testing and qualification of the foil bearings, multifoil insulation, and emissivity coatings. Design of the turbine-alternator and the recuperator will be completed and fabrication operations will begin. This schedule will support initiation of a fully integrated system test by the end of FY 1991. Results of these tests will provide confirmation of the system design basis and firm cost and schedule estimates. These tests will also demonstrate to NASA and DOD mission program managers that the TECS technology is ready for specific mission applications, with the power conversion modules capable of using radioisotope heat sources, as well as those potentially from small reactors and solar heat systems.

REMEDIAL ACTION

The objectives of the Remedial Action and Waste Technology Program are to stabilize radioactive wastes or perform decontamination and decommissioning at contaminated DOE and legislatively-authorized non-government facilities and sites; demonstrate the solidification of high-level waste for disposal; facilitate establishment of a reliable national system for managing and disposing of low-level radioactive wastes; and develop beneficial uses of nuclear byproducts. Successful execution of this program is a key part of the Department's commitment to continue to protect public health and safety and to assure a safe and clean environment in connection with its activities.

The major Remedial Action and Waste Technology activities include (1) the Formerly Utilized Sites Remedial Action Project (FUSRAP), remedial action at sites formerly utilized by the Department's predecessor organizations or assigned by Congress; (2) the Uranium Mill Tailings Remedial Action Project (UMTRAP) for 24 inactive uranium mill tailings sites and several thousand associated vicinity properties (Public Law 95-604); (3) the Surplus Facilities Management Program (SFMP), for certain radioactively contaminated DOE facilities declared surplus and resulting principally from civilian nuclear energy programs; (4) the West Valley Demonstration Project, which will solidify high-level radioactive wastes at West Valley, New York, for final disposal (Public Law 96-368); (5) the Low-Level Waste Program, which, among other things, provides technical assistance to States and regions to assist them in developing new capacities for the disposal of low-level radioactive waste (Public Law 99-240); and, (6) the Byproducts Utilization Program, which DOE proposes to phase out in FY 1990.

The requested funds for the Remedial Action and Waste Technology Program are distributed among the program elements as indicated in the following table.

Program Element	FY 1989 Appropriation	FY 1990 Request
	($ in Millions)	
Remedial Action and Waste Technology		
Formerly Utilized Sites	$ 22.2	$ 15.0
Uranium Mill Tailings	111.0	96.0
Surplus Facilities	47.0	30.0
West Valley	66.5	90.0
Low-Level Waste	5.0	5.0
Byproducts Utilization	0.6	0
Program Direction	2.4	2.6
Total	$ 254.7	$ 238.6

FORMERLY UTILIZED SITES REMEDIAL ACTION PROJECT

The Formerly Utilized Sites Remedial Action Project (FUSRAP) is comprised of remedial actions at former nuclear processing facilities which became radioactively contaminated as a result of Manhattan Engineer District or Atomic Energy Commission (MED/AEC) activities and which have not been decontaminated sufficiently to meet current public health and safety guidelines. FUSRAP also includes certain contaminated sites specifically assigned to DOE by Congress for remedial action. The Department's Oak Ridge Operations Office has the lead field management responsibility for implementing FUSRAP.

To remedy the situation at these contaminated sites, either the contaminated material will be stabilized in place, with restrictions placed on the use of the site, or the contamination will be removed and disposed of at another location. Remedial action is needed at 24 sites, formerly utilized by MED/AEC, based on a review of the involvement of these predecessor agencies in previous site activities. The review of sites involved in past activities of MED/AEC was completed in CY 1987.

Additional sites may be added to the program once followup site radiological surveys are completed.

Congress added four sites to the program when it enacted Public Law 98-50, the FY 1984 Energy and Water Development Appropriations Act, and directed that DOE initiate a decontamination R&D project at these sites as a priority action. With enactment of Public Law 98-360, the FY 1985 Energy and Water Development Appropriations Act, Congress directed DOE to reacquire the former St. Louis Airport site and use it to dispose of waste from the cleanup of the nearby Latty Avenue site and vicinity properties. This brings the total number of sites in FUSRAP to 29.

The general approach to FUSRAP projects is to give priority to the cleanup of contaminated residential properties and to store the waste temporarily on each processing and storage site. The cleanup of residential properties in Maywood and Lodi, New Jersey, contaminated with material from the former Maywood chemical site (now owned by the Stepan Company), began in FY 1984. In FY 1989, storage of all excavated wastes from vicinity properties will be completed. These are stored on an 11.7 acre portion of the Stepan Company property, which Stepan donated to DOE in 1985.

At Wayne, New Jersey, remedial actions are complete and long term surveillance has begun until such time as a disposal site for the waste is established in New Jersey. The State of New Jersey has been requested to nominate candidate locations in the State for DOE use in establishing a site for disposal of the estimated 120,000 cubic yards of waste at Wayne, as well as another estimated 360,000 cubic yards of FUSRAP waste at Middlesex and Maywood, New Jersey.

At the Colonie, New York site, the final group of vicinity properties were decontaminated in 1988 with interim storage of the waste at the site. In 1988 and 1989, the Department plans to conduct a Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) response action at the Seaway, New York, site to provide for long-term, in-place management of the waste.

Also in New York in 1988, we began the process and held public meetings regarding the required environmental analyses documents for the Colonie, Linde, and Ashland 1 and 2 sites. These environmental documents will be consistent with National Environmental Policy Act (NEPA) and CERCLA requirements. Site characterization data to be included in the environmental documents will be collected at all the sites, characterization will be completed in 1989, and the draft remedial investigation report will be published in early 1990. We are closely coordinating our activities with EPA and the State of New York in light of their oversight roles under NEPA and CERCLA for these sites.

Characterization activities in Missouri at the Latty Avenue, St. Louis Airport, and downtown sites continued in 1988. These activities will be completed and the results will be issued in 1989. DOE is currently negotiating with the City of St. Louis to reacquire the Airport site and use it for disposal as directed by Congress. Additional plans in FY 1989 for these sites are subject to the outcome of these negotiations.

URANIUM MILL TAILINGS REMEDIAL ACTION PROJECT(UMTRAP)

Public Law 95-604, the Uranium Mill Tailings Radiation Control Act of 1978, assigned to DOE the responsibility for conducting remedial action at 24 former uranium ore processing sites and several thousand contaminated vicinity properties. Nine of the sites are designated as high priority, six as medium priority, and nine as low priority. The Department's Albuquerque (New Mexico) Operations Office has the lead field management responsibility for implementing UMTRAP. The Act provided authority for remedial action by the Department for a period of 7 years following promulgation of standards by the Environmental Protection Agency (EPA), which occurred in March 1983. However, it became apparent several years ago that the work could not be completed within the 7-year authorization period because of the scope and nature of the work required to comply with the EPA standards, the large number of sites and vicinity properties, and the impracticality of seeking or obtaining the large annual appropriations required to complete the work within the 7-year period. Public Law 100-616, the Uranium Mill Tailings Remedial Action Amendments Act of 1988 extends the Department's authority to perform remedial actions through the end of FY 1994, based on budget projections in excess of $110 million per year through FY 1991.

The program strategy is to focus near-term activities on the higher priority sites and on vicinity properties. Remedial actions are being conducted in accordance with cooperative agreements negotiated with the affected States and Indian tribes. Federal funds cover 90 percent of the remedial action costs (100 percent for the sites on Indian lands), and the States provide funding for the remaining 10 percent. The type of remedial action for the processing sites is to stabilize the mill tailings in place, where possible, or to remove them to a new disposal site. In either case, the final disposal sites will be Federally owned and maintained under NRC license. Engineering plans and environmental documents are prepared for each site cleanup and disposal operation. Concurrence by the NRC and the affected State or Indian tribe is required for the remedial action plan at each site. The project also involves the cleanup of an estimated 4,925 contaminated vicinity properties mainly in the Grand Junction, Colorado, area. By the end of FY 1988, cleanup activities were completed on 54 percent of these properties.

On January 5, 1983, EPA issued final standards for the disposal and cleanup of the inactive mill tailings sites under UMTRAP. These standards were challenged in 1985 before the Tenth Circuit Court of Appeals. The court dismissed all challenges except one--it set aside the groundwater provisions and recommended that EPA issue standards of general applicability. On September 24, 1987, EPA issued its proposed rule and the comment period closed January 29, 1988.

In its comments to EPA on the proposed rule, DOE supported the basic intent of the proposed standards to protect human health and the environment. However, concern was expressed that it would cost the Federal Government on the order of $1 billion to restore groundwaters contaminated by the inactive mill tailings without a commensurate quantification by the EPA of the health benefits gained by the expenditure of this large amount of money. We believe that the cost of implementing the proposed groundwater restoration program is far too great for the modast potential health effects projected. We anticipate that the EPA will issue its final rule in April 1989.

During FY 1989, work is underway or planned at 13 processing sites. The work at Salt Lake City, Utah, and Lakeview, Oregon, will be completed, as well as cleanup of vicinity properties at Edgemont, South Dakota. Onsite work will continue at Ambrosia Lake, New Mexico; Durango, Colorado; Mexican Hat, Utah; Rifle, Colorado (2 sites); Riverton, Wyoming; and Tuba City, Arizona. Processing site remedial action will begin at Green River, Utah; Grand Junction, Colorado; and Monument Valley, Arizona. Processing site remedial action will begin and be completed at Spook, Wyoming. Remedial action on an estimated 858 vicinity properties will also be completed.

During FY 1990, remedial action will be underway at 8 processing sites and an estimated 881 vicinity properties will be completed. Remedial action will be completed at the Durango, Colorado; Green River, Utah; Riverton, Wyoming; and Tuba City, Arizona, sites. Site remedial action will continue at Ambrosia Lake, New Mexico; Grand Junction, Colorado; Mexican Hat, Utah; and Monument Valley, Arizona. Remedial action work will be suspended at some low priority sites due to budget constraints. Surveillance and maintenance activities will be conducted at completed sites (Canonsburg, Pennsylvania; Green River, Utah; Lakeview, Oregon; Salt Lake City, Utah; and Shiprock, New Mexico).

SURPLUS FACILITIES MANAGEMENT PROGRAM

The Surplus Facilities Management Program (SFMP) provides for the safe management and disposition of certain surplus facilities radioactively contaminated from DOE civilian nuclear energy development activities. The decontaminated facilities and sites are to be returned to other productive use, where appropriate, and are grouped into 41 projects under this program. Cleanup has been completed on 11 of the 41 projects currently in the program. Priorities are established and project schedules are developed within available funding, through analysis of public health and safety, legal, economic, and work continuity factors for each site. Work on individual projects is managed by various DOE field offices as assigned, while overall program management is carried out at the Headquarters level.

Decommissioning of the Shippingport Atomic Power Station, which began in September 1985, will continue through project completion in early FY 1990. The reactor pressure vessel has been removed from the containment structure and is scheduled to be shipped in early 1989 by barge to the Department's Hanford Reservation near Richland, Washington, for disposal as low-level waste. The Department will not proceed with this shipment until we have resolved technical issues related to its disposal. The Department has cooperated with the NRC and the Electric Power Research Institute (EPRI) in obtaining samples and components of the plant for aging studies, and is also participating in an international exchange of decommissioning technology sponsored by the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD).

The Department has a Federal Facility Agreement with EPA for the Weldon Spring Site Remedial Action Project, which involves remediation of and disposal of the waste from the 222-acre Chemical Plant (which includes a 53 acre raffinate pit area) and a 9-acre limestone quarry which was used for disposal of trinitrotoluene (TNT)-dinitrotoluene (DNT) and radioactive wastes. Since portions of the site were previously used by the Army, DOE and the Army have signed a Memorandum of Understanding (MOU) whereby the Army annually provides partial funding for this project. Weldon Spring is on the EPA Superfund National Priorities List (NPL). Activities in 1989 include (1) completion of the chemical and radiological characterization; (2) preparation of the Remedial Investigation/Feasiblity Study-Environmental Impact Statement (RI/FS-EIS); and (3) expedited response actions to eliminate potential health and safety hazards such as removal of PCB transformers and outside asbestos, electrical poles and lines, and limited vicinity property cleanup. In FY 1990, we plan to issue the draft RI/FS-EIS which will support the decision on the cleanup of the site and disposal of the waste. All activities at the site are closely coordinated with EPA Region VII and the State of Missouri.

At Monticello, Utah, mill tailings continue to be removed from residential properties in FY 1989, leaving about 13 of the 75 properties to be completed in FY 1990 and FY 1991. The mill site is expected to be placed on the NPL by EPA in FY 1989. In December 1988, EPA, DOE, and the State of Utah signed a Federal Facilities Agreement under CERCLA Section 120 covering the mill site and vicinity properties to expedite their cleanup. An RI/FS document will be completed for the Monticello mill site, and remedial action is expected to start in late FY 1990, contingent upon the issuance of a Record of Decision. If a decision is made to relocate the tailings, the project cost and schedule will be significantly impacted.

Other activities in FY 1990 will include continuation of site and facility disposition projects at the Santa Susana Field Laboratory, in California; the Oak Ridge National Laboratory, in Tennessee; and, the Los Alamos

National Laboratory (LANL), in New Mexico. Decommissioning of the Experimental Boiling Water Reactor, at the Argonne National Laboratory in Illinois, will continue and cutting and packaging of the reactor pressure vessel will be initiated. At LANL, decommissioning of the Ultra High Temperature Reactor Experiment will be completed. Work on the decontamination of plutonium-contaminated facilities at Mound Laboratories in Miamisburg, Ohio, will continue and be completed in FY 1991. At the Battelle Columbus Laboratories in Ohio, activities will be limited to surveillance and maintenance. Cleanout of radioactively contaminated hot cells at the Pacific Northwest Laboratory, in Washington has been deferred until FY 1995.

WEST VALLEY DEMONSTRATION PROJECT

The objective of the West Valley Demonstration Project is to demonstrate the solidification of high-level nuclear wastes for transportation and disposal as mandated by Public Law 96-368, the West Valley Demonstration Project Act. An integrated production-scale development and demonstration project for treating approximately 600,000 gallons of high-level nuclear waste is being carried out at the Western New York Nuclear Service Center, near West Valley, New York.

Major activities to be performed as part of this project include (1) decontamination required to prepare existing facilities and equipment to accommodate the solidification project; (2) removal of high-level waste from underground storage tanks; (3) development, design, construction, and operation of systems and support facilities for the solidification of the high-level waste; (4) acquisition of containers for the permanent disposal of the solidified waste; (5) storage and transportation of the solidified waste to an appropriate Federal repository for permanent disposal; (6) decontamination and decommissioning of the waste tanks, facilities, hardware, and material used in carrying out the project; and (7) disposal of low-level and transuranic wastes derived from project activities.

The supernatant high-level liquid waste above the sludge layer in the underground storage tanks represents nearly 90 percent of the volume and 50 percent of the radioactivity of the stored high-level waste. This supernatant is being treated and its volume reduced during the period FY 1988-1994. The low-level waste stream from this processing system is being immobilized in cement and stored at the site in a shielded cell. The separated high-level waste portion will be stored and later blended with the sludge from the storage tanks and glass formers prior to producing canisters of vitrified high-level waste.

Facilities to significantly improve the capability of the Project to reduce the volume of low-level wastes began operations in FY 1988. They will be operated as needed throughout FY 1989 and FY 1990 to support various project activities.

Non-radioactive testing of the glass melter system and a substantial portion of the design of the overall vitrification facility will be completed in FY 1990. Fabrication and installation of components and systems for the vitrification facility will continue throughout FY 1990.

LOW-LEVEL WASTE PROGRAM

The Low-Level Waste Program provides technical assistance to States and compact regions in developing new capacity for the disposal of low-level radioactive waste in accordance with Public Law 99-240, the Low-Level Radioactive Waste Policy Amendments Act of 1985. This legislation assigned individual States the responsibility for the disposal of low-level radioactive waste generated within their borders, with the exception of such waste generated as a result of certain Federal activities and non-DOE generated low-level waste exceeding the limits established by the NRC for Class C low-level waste. The formation of regional compacts among States to carry out their responsibilities is encouraged by the Act. To date, nine compact regions incorporating 41 States have been formed and have received Congressional consent.

Under this program, DOE administers an escrow account created by the Act, from which rebate payments are made to States that are in compliance with the Act's milestones. These funds, by law, can be used only for low-level waste management purposes. DOE determined each State's compliance status for the milestones that occurred on July 1, 1986 and January 1, 1988. After the 1988 milestone, DOE rebated approximately $4 million to the States in accordance with requirements of the Act. Procedures and guidelines have been developed for evaluating each State and compact region's eligibility for escrow account rebates following the January 1, 1990 milestone.

During FY 1989, the Low-Level Waste Program will conduct the various reporting and administrative activities required in the Act and will focus on meeting the generic technical needs of the States and compact regions as they work to select sites and develop new disposal facilities. DOE submitted two prototype disposal technology license applications to the NRC for its review, in order to elicit that agency's views on significant licensing issues of interest to the States. NRC's comments are expected to be available on both reports by early FY 1990.

In FY 1990, DOE will continue to provide technical assistance to States and compact regions to support the selection and development of new low-level disposal facilities. As States and compact regions proceed at different schedules toward the establishment of new disposal sites, the Low-Level Waste Program expects that technical assistance will be directed more toward specific needs of individual States and compact regions. DOE is currently developing a strategy plan for disposal of greater-than-class C low-level waste. In FY 1990, the Department expects to provide for acceptance of limited amounts of greater-than-class C low-level waste for disposal. The Department will also continue to carry out its administrative and reporting requirements to Congress, as required by law.

BYPRODUCTS UTILIZATION

In FY 1986, Congress directed DOE to initiate a civilian byproducts utilization activity that emphasized food irradiation applications. This activity is carried out under the Advanced Radiation Technology Program whose goal is the development of technology for the beneficial use of nuclear materials. Irradiation of food and other agricultural commodities has been emphasized in cooperation with States and other Federal agencies.

In 1987, DOE signed cooperative agreements with all designated organizations for development of commodity irradiation projects in Florida, Iowa, Hawaii, Washington, Alaska, and Oklahoma. These States were selected based on their proximity to major agricultural commodity production and processing centers and the potential benefits to be derived by their use of food irradiation processing. A prime objective has been to demonstrate for food producers, processors and the consumer that irradiation of agricultural commodities can be a beneficial and unique method of processing and preserving certain food groups.

Congress did not provide FY 1989 funding to continue the food irradiation projects, and the Department is requesting no FY 1990 funding for this activity. However, using prior year funding, plans are being made to continue with the Iowa and Florida projects in an effort to meet the objectives for this activity established by Congress in FY 1986. The Department plans to transfer research results and designs for specific facilities to the other four project sponsors and bring DOE participation in these projects to an orderly termination in FY 1990. R&D efforts to improve radioluminescent lighting system for use at remote airfields were continued in FY 1989. These research and development activities will also be phased out in FY 1990.

CONCLUSION

Nuclear energy is a key element required to provide America an adequate supply of energy at a reasonable cost. Based on conservative projections, we know there will be a need for new electrical generating capacity by the 1990's to replace old plants and to meet increased demand of our expanding population and economy. Utilities should be able to consider building nuclear plants to meet a portion of this new capacity, yet the nuclear power option faces numerous interrelated technical, institutional and public perception problems that threaten its future use in the United States.

At this critical point in its development, we must address and resolve the issues confronting nuclear power, including establishment of an effective and predictable regulatory and institutional environment; revitalization of the light water reactor option; development of the other advanced nuclear reactor systems with the potential for breakthroughs in economics, safety, licensability and waste management; developing space nuclear energy power supply systems to meet the expanding needs of user agencies such as NASA and DOD; operating the Isotopes and Production Distribution program in a business-like manner through improved isotope pricing policy, production and financial control; and continue in the Remedial Action program to achieve progress in protecting the public health and safety and assuring a safe and clean environment while the program is experiencing stretchout. Our FY 1990 budget takes steps toward these goals and with the help of this Committee we can ensure progress in achieving them.

DISCUSSION

Mrs. **Lloyd**. Thank you. I want to compliment you on your excellent statement—well prepared.

We have many friends of this Committee that are here today. Some of you I have known ever since I've been a Member of the Science Committee. I would like to recognize the former Chair of this Committee, The Honorable Mike McCormick who is with us today. Mike, it's always good to see you and have you a part of our hearings. I'm sure Mr. Morrison is equally glad to see you.

Ms. Novak, I would like for you to give us a little bit more information on your Advanced Reactor Severe Accident program. Why do you feel this is a valuable R&D program? I'd like you to tell us a little bit more about it.

Ms. **Novak**. The Severe Accident program that we are undertaking right now pulls together the data and analysis that the NRC and the DOE have been compiling over the last number of years and allows it, for the first time, to be actually applied to the development and design efforts that we have ongoing.

Mrs. **Lloyd**. These are, what, the lessons learned that we've been paying for?

Ms. **Novak**. We're taking out of it the lessons that are there, inherent in the data and analysis that we've all been pulling together, and applying it actually to the technologies.

Mrs. **Lloyd**. I notice that the program was cut from $4.0 to $2.0 million.

Ms. **Novak**. That is correct. Because of the application of this program in so many regards and bringing the material together, and because it was going to be used to support some efforts on one of the advanced evolutionary designs, it was no longer needed to fully put that money in in the fiscal 1990 budget request.

Mrs. **Lloyd**. I'm going to have to look at this program again. In my opening statement I referred to some of the contracts with the private sector that I was concerned about. I was wondering how you felt about the $1.0 million in the proposed funding for combustion.

Is this consistent with the level of funding when the agreement was signed between the Department of Energy and Combustion?

Ms. **Novak**. Yes. As I understand it, this agreement was actually signed sometime in about early 1987.

Mrs. **Lloyd**. In '87?

Ms. **Novak**. In early 1987 when the agreement was actually signed, though there was considerable discussion and effort previous to that which I think began in 1985 or thereabouts.

When we concluded this agreement and had a discussion, the intent on both Combustion Engineering and the Department of Energy was that we would make an attempt to certify their advanced program in two pieces. That is, the nuclear island and the balance of plant.

At that time that was very consistent with NRC's policy previously established in 1985 and 1987, thereabouts, when we were concluding the agreement.

Recently, the NRC—I think it was late last year or in the fall—altered the requirements to include both the nuclear island and the balance of plant. That substantially changed the program that Combustion Engineering and ourselves were intending to start out on, and therefore in order to meet those requirements, both Combustion Engineering and the Department of Energy need to take that $1.0 million, reconfigure what we're going to go forward with and how, and we also in fact need to find new sources of funding.

Mrs. LLOYD. How much is this program? I've got so many questions to ask that I can't spend too long on it.

Ms. NOVAK. In order to do, if we could start tomorrow morning, putting aside this fiscal structure, with the two balance of plants we would need approximately—I think it's about $4½ million for two years. If the Department of Energy and Combustion Engineering just said tomorrow morning we're going to start doing it under the newly altered requirements from the NRC in the two phases—we're going to do them at one time—we would need about a two-year funding. I'm sure that Combustion Engineering would—correct me——

Mrs. LLOYD. They indicated they need $4½ million for 1992.

Ms. NOVAK. So if in this year, and all things taken into account, which they always must be, it was agreed to between the Department and Combustion Engineering that either in fiscal 1990, through supplemental reprogramming, or in fiscal 1991, that that was necessary and important and valid to go ahead with, that's what we would have to agree to come forward with, and whatever share, from whatever party seemed appropriate.

Mrs. LLOYD. Turning to a project in my district, it's my understanding that advanced instrument and control development activities at the Oak Ridge National Laboratory and the University Research program as well in robotics are proposed for termination in 1990.

The robotics program is certainly a very useful program. Why did you not provide the research funds for this?

Ms. NOVAK. Well, the control and instrumentation decision was a factor based on two things. First of all, most of the technologies, as I understand it, have already chosen—there was significant enough work done already in that program that allowed the technology to choose their control and instrumentation components and factors based on that and other work.

On the Light Water Reactor side, frankly, the effort that we were going along and doing, it's cheaper for them to buy it off the shelf. And there is much out there that is available for them to choose from. And the other technologies have made their choices.

Those factors came together with the overall budget constraints we faced in this nuclear energy R&D program to give it a lower priority at this time.

Mrs. LLOYD. I'm sorry we don't have time to ask followup questions on this.

Turning to the MHTGR program, you've signed four contracts with the industrial participants on the MHTGR civilian program. It is my understanding that industry expects DOE to contribute about $60 million to this program.

Is this correct? And if it's not, how do you reconcile this with the budget, Ms. Novak, for this program—with the contracts that have been signed, if this is a contractual agreement?

Ms. **Novak**. I believe the $60 million emanates from a proposal amongst the parties, the contractual parties and the Department of Energy, that in fiscal 1991 for the design work that we were going down, the Department of Energy would provide, I think it was estimated to be $50 million and $10 million from the private sector. And I think that was fiscal 1991 numbers.

Jerry, you might want to elaborate on this some further as a result of this budget request. I'd like to introduce Jerry Griffith, who is the Associate Deputy Assistant Secretary for Advanced Reactors, to respond on this complicated issue.

Mr. **Griffith**. Thank you, Madam Chairman.

When we negotiated the contracts with these organizations, the scope and pace of the MHTGR program was not well known. So we developed contracts to fully fund what would be a scope of work of a maximum nature to the Department of Energy to complete the development of the MHTGR, so that the total amount of these contracts were over $400 million; I believe $421 million.

As a result of negotiations that were then conducted with the participants for a potential project, a cost sharing arrangement baseline was essentially negotiated last year, and as Ms. Novak has indicated, that called for funding of $60 million by the partners in '91, but it called for funding of $38 million in FY '90; $30 million from the Department and $8 million from the participants, industrial participants.

Subsequent to these negotiations, the Department made a decision to pursue a two New Production Reactor development scheme. Under those arrangements one of the production reactors would be an MHTGR similar to the civilian reactor.

As a result of that decision, additional budget in FY '90 is now available for the MHTGR development of about $115 million, of which $57 million or as much as $57 million could potentially contribute to the civilian MHTGR.

Our best estimate at the time that we submitted the $15 million budget was that at least $15 million of additional development that we had proposed to do on the civilian side could be captured from the military application.

Mrs. **Lloyd**. In other words, this money will come out of the military application part of the program? Is that what you're saying?

Mr. **Griffith**. In some manner we will capture that scope of work to support the civilian program. Whether money would be transferred, those arrangements have not been discussed. But the development efforts that must go on are similar and could support the pace of the government's portion.

Mrs. **Lloyd**. Jerry, what if the Congress does not fund the new production MHTGR? How much should we then appropriate for the civilian program?

Mr. **Griffith**. Our budget called at the time to support $30 million worth of development on that baseline agreement.

Mrs. **Lloyd**. I'm going to stress that I think it is important when contracts are signed that we live up to our obligations as the signatories of a contract.

Ms. **Novak**. I think that's a fair comment.

Mrs. **Lloyd**. Mr. Morrison?

Mr. **Morrison**. Thank you, Madam Chairman.

I've had a concern and I have to start off my questioning by expressing that concern that the plans that are out there are in fact going to meet our commitment to America as far as the ability of nuclear power to fit into the future. And I appreciate much of your testimony, including the pressure on the licensing procedures.

Do you foresee a pattern of Advanced Light Water Reactors and advanced reactors and ultimately fusion fitting into the proper timetable and track for America's energy future? Are you comfortable with the figures you have in front of you on our meeting that obligation?

Ms. **Novak**. I am more comfortable with the figures, if I can be forthcoming on this, than I am with whether the government and the industry are always united enough to accomplish things; whether within the government and the various parties that work, that we are always united enough and heading towards the same goal at the same time. Sometimes it appears to me from my experience that there is sometimes more of a problem with the quality of all of our joint efforts together than it is the quantity of money we're putting in at any given moment.

Mr. **Morrison**. I trust that at times those two are related.

Ms. **Novak**. At times they are, but in relation to the general question——

Mr. **Morrison**. Thank you.

I have trouble in a couple of areas of what I would consider responsibilities at OMB. For instance, we're paying now for the first time a charge for SWUs on enriched fuel. Is OMB handling this so that, while we're shifting pockets, we're taking money out of, it still comes out of the Treasury—are we being penalized under the Nuclear Energy Research Program because of this shift that puts more cost into some of our programs?

But is there an offsetting factor there somewhere?

Ms. **Novak**. The Department's Uranium Enrichment Program has always directly charged the programs in the Department that control the facilities that require it. However, for example, at the Hanford facility there was for a long period of time an inventory stockpile, and it has been I think something like 10 to 15 years since they required the purchase of any additional enriched uranium.

Unfortunately, that time arrived at the same time as all of the other restraints. So the policy and practice has not changed. The cost and the need to purchase this came at an unfortunate time from both the overall budget, the pressures in the program, as well as the cost of uranium.

Mr. **Morrison**. And, of course, it is going to take some extra effort, and we trust you will be part of that effort to explain to Appropriations Committees that these aren't really anything new that we're doing. It's just that there is a price tag associated with it now.

Ms. **Novak**. Yes, I will do that.

Mr. **Morrison**. Thank you. That's appreciated.

I'm concerned with slippage SP-100 program. It keeps getting stretched out. Are you concerned about the viability of that program? Are we going to be ready with SP-100?

The President in his speech talked about new emphasis on the Manned Space Station and so forth.

Ms. **Novak**. Yes. That was a very good message to all of us at the Department which we welcomed quite a bit, as well as I'm sure that NASA did. We are very concerned about this program and the continuous slippage. We are concentrating on the essential nuclear reactor tests and components that are central to the idea of it being a space reactor, and working closely with NASA and DOD to assure that the essential things we have to test, much like the essential part of a nuclear power plant being the nuclear island, is not slipping in and of itself.

We are hoping to go forward with the nuclear assembly test as soon as possible, but I can't pretend to not be concerned that we are cutting very close to the edge when we move dollars from there, and being concerned that NASA and the DOD have continuously been willing and wanted to provide us money and they, too, have found out that because of various budget cuts they were unable to provide the full funding.

It has hit all three of our agencies now. This is the first time it has happened with DOE and I hope that it won't have to happen in the future.

Mr. **Morrison**. Isn't that a logical responsibility within OMB to make sure that these program remain viable, even though the funding dollars, the sources need to come from a variety of locations?

Ms. **Novak**. I think it's the major responsibility of the Departments to make sure the programs are not harmed. OMB certainly has a role in helping the Departments make those decisions and priorities by virtue of assessing the budgets and overall bottom lines.

The difficulty probably emerges as much from the fact that even within OMB, as is true in the Congress, the budget examining program that oversees the Department of Energy, Nuclear Energy, Space Power, is different than that which oversees NASA and DOD.

We're hoping that the three agencies can come forward, both within the government Executive Branch and to the Congress, to consolidate that and get a general approval and recognition that we need to centralize this program more than we are doing.

Mr. **Morrison**. I couldn't agree with you more. We find it both in SP-100 and in the 238 mission potential, for instance, that FFTF.

Mr. Chairman, with your indulgence, I have one question Mr. Buechner wanted me to ask, if I may do that.

Mr. **Stallings** (presiding). Without objection.

Mr. **Morrison**. And then he has a series of other questions that I will submit for the record.

Mr. Buechner expresses concern about radioactive contamination at the St. Louis Airport and other sites in St. Louis and St. Louis County. And there are budget reductions from the amount originally planned.

His questions are: What is a rationale for reducing funds for Weldon Springs, especially when these cuts in the project's annual timetable could double both the $400 million total cost and the 12-year timetable?

A secondary question: When President Bush visited St. Louis several weeks ago and made a pledge to restore some of the cleanup money, have you had an opportunity to learn whether these funds will be restored?

Ms. Novak. As to the first part, the rationale centers primarily on the fact that the budget mark which we had to deal with under the budget constraints forced us to cut back in each of our programs in some way. We tried to apportion it by benefit to the public, whether it be through environmental cleanup or development of a nuclear technology or space and defense program, weigh in the times and the needs of the public, but in some ways each of our programs has contributed to that.

These two sites fall under particular programs that any slight—the way that they are budgeted, planned, and scheduled—that any slight permutation in the schedule and planning causes much more dislocation than it would appear those dollars do.

That's what has happened on the formerly utilized remedial action sites which St. Louis falls under, as well as the Weldon Springs site. It's more clearly a matter of the reduced budget constraints that we faced in putting together the whole budget.

Mr. Morrison. Has there been reprioritization of the risk involved to the public in some of these sites?

Ms. Novak. There has been in the Department within each of these programs that fall under remedial action—the surplus programs. The FUSRAP, as we call them formerly, utilized—the uranium mill tailings—all have been progressively ratcheted as to the threats from a public health and safety or environmental degradation or need for cleanup.

In addition, those different line items on programs of remedial action are themselves given a level of priority based on those considerations. So that those two broad layers of review led to a decision on which ones, and the trouble is it's an escalating domino kind of effect. As we go down, each one shoves the next one a little bit more.

Mr. Morrison. Do you have any answer to the question about President Bush's input when he was there?

Ms. Novak. I read the newspapers as well and heard the comment. I have not heard officially or directly any further followup of that in the Administration, or have been able to at this time to verify that or seek guidance on what we are to do.

We have talked with the Office of Management and Budget which is also trying to verify the situation. I believe that the President left the country shortly thereafter and seems a little busy this week, too.

Mr. Morrison. We'll tell Mr. Buechner to get back to the President.

Thank you very much, Mr. Chairman.

Mr. Stallings. Ms. Novak, I'd like to follow up just briefly on an earlier comment that was made. This deals with a contract that the Department signed with General Electric.

Now, I understand that within a month of the signing of the contract with G.E. for a PRISM development program, the Administration dropped $10 million from the budget expected in the contract.

G.E. tells me that this level of funding would cause them to start closing out the program. Is this correct?

Ms. **Novak**. That is not, as I understand it. I believe that we actually had, I think, it was originally $14 million in there that changed, and the $14 million was predicated—and I would certainly like Jerry Griffith again to comment on this and correct me.

Mr. **Stallings**. Please.

Ms. **Novak**. That $14 million as I recall was predicated on two separate concepts: this G.E. concept and another concept that we were evaluating, in choosing the PRISM that reduced the need for going ahead with both programs. That, coupled with cost-sharing initiatives the government would like to put into effect as much as possible, and other international funding levels is, I think, what caused the reduction.

But, Jerry, could you expand briefly on that to make sure I was correct?

Mr. **Griffith**. Yes.

I think Ms. Novak has covered the basic background. The Department had been funding two design studies at $14 million. We had reached enough level of detail in the design that we could not afford to dig deeper in both designs, so we made a choice and came down to one design.

Also, the policy of the Department to try to obtain more cost sharing, both international and domestic, eventually led to a budget of $4 million with a priority on trying to develop more cost sharing in that manner.

Mr. **Stallings**. But, as I understand it, the Department signed the contract with G.E. because of their—apparently the design was more favorably accepted. Do we sign contracts and then hold money out of the budget, or go back to the contractor and say, gee, we don't have enough money to go through with this contract?

I mean that doesn't make a lot of sense to me either fiscally or if we want good research done.

Mr. **Griffith**. In general, contracts are always negotiated for the maximum amounts that would lead to a reasonable pace of the program, and invariably there is language to support lesser amounts as authorized and appropriated by Congress.

There are provisions to proceed at slower paces if such arrangements work out.

Mr. **Stallings**. Do we give the contractors the same options when they sign a contract with you?

Mr. **Griffith**. The contractor takes the money and does the work. He has the option to do the work we pay for, or not.

Mr. **Stallings**. But we don't treat them quite the same on the other side, then. That bothers me because I think that we expect these companies to do the kind of research that we want and we give them some directions. But if we don't live up to the expectations that we present, I wonder if we're really getting the kind of quality work that we will get, not now, but in the long term because I would expect that some of these contractors are going to start looking elsewhere to do their business if we can't be a trusted participant in that business.

Mr. **Griffith**. I have to agree with you. It would be ideal and much better if the Department could proceed exactly on the funding level that was agreed to in all the programs that we run, but invariably other things will happen and programs will have to be adjusted, some of them stretched, priorities put elsewhere.

And in this particular case, our priorities are for the development of the Metal Fuel and other R&D programs which must support that design. And in the conceptual design phase of the PRISM design, it is easier to slow that at this time. So when the budget priorities were reviewed, that was the decision that was made.

Mr. STALLINGS. Now, G.E. tells me that if that continues, they will essentially have to dismantle much of what they have done. I am quite impressed with the Liquid Metal Project. I think there's a lot of merit to it. I think it's something that we need to look at in terms of our overall energy policy, and I would think that the strides that have been made in the last few years could possibly be negated by terminating or canceling or dismantling that operation at this moment.

Mr. GRIFFITH. Yes. I, too, am impressed with the foreign cooperation and participation that G.E. has developed in this program. They are to be commended.

Mr. STALLINGS. Mr. Fawell.

Mr. FAWELL. Thank you, Mr. Chairman. I'm sorry I wasn't listening closely to the previous answers, and I hope my questions may not be repetitive, but I know they are zeroing in on the same basic area.

I've heard and we continue to hear so very much about the importance of not overusing our fossil fuels and protecting our environment, and I've always been impressed about the various alternative energy sources which we have available.

Yet it seems that we often times can put a great deal of money—I'm not knocking necessarily the efforts in regard to acid rain—talk about billions to treat the ultimate effect. And we don't seem to emphasize the money that ought to be put in regard to the R&D for these alternative energy sources when we have "Spaceship Earth" kind of in deep trouble. Even if it weren't in deep trouble, I think a number of witnesses have said you can't go wrong by moving full force ahead in regard to these potentials, whether it's Liquid Metal Reactor improvements or Fusion or Hydrogen.

Certainly the Liquid Metal Reactors I am concerned about. When I see the advanced reactor budget being cut to $43 million from the fiscal 1989 appropriation level, I must confess some parochial interest because of what I've seen of the Integral Fast Reactor Program at Argonne, for instance.

And I wonder if one could detail, if not now then later for the record, the activities which will not be conducted and the location and number of employees expected to be impacted by these cuts. I note especially the major reduction in the Integral Fast Reactor Demonstration program.

I am concerned about this. It seems we're going backwards no matter all the publicity about how we are, permanently perhaps, damaging our environment.

It's a terribly long question and I apologize for that, but could you wade into that area.

Ms. NOVAK. I certainly can in the general sense that I agree with you, I believe the Department agrees with you, and I certainly know that Admiral Watkins, if confirmed by the full Senate will feel and state that very strongly.

I will have to provide for the record the specifics of the funding cuts, where they are and how they affect those programs, people and facilities that we have currently available by the Department.

Mr. **Fawell**. I would appreciate that being done.

Ms. **Novak**. Okay. I'd be glad to provide that for the record.

[The information follows:]

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Insert for the Record

The approximately $43 million decrease in fiscal year 1990 Advanced Reactor research and development funding was offset by a corresponding increase in Facilities funding. The combined fiscal year 1990 funding request for the Advanced Reactor research and development program and the supporting test facilities is $213.7 million, or about $1.0 million greater than the fiscal year 1989 appropriation.

At the Argonne National Laboratory, the integral fast reactor/metal fuel cycle research and development program plan calls for $19.5 million in fiscal year 1990. The Advanced Reactor research and development funding request for the integral fast reactor/metal fuel cycle research and development in fiscal year 1990 is $6.1 million. Facilities funding for the Argonne National Laboratory, however, has increased from $52.3 million in fiscal year 1989 to $71 million in fiscal year 1990. In addition, we anticipate $8 million to be provided by Japan pursuant to a collaborative research and development contract that is now under negotiation. Accordingly we do not anticipate any adverse impact on staffing or facilities at the Laboratory. The highest priority in the integral fast reactor program will be the development and demonstration of the pyrometallurgical reprocessing and fabrication of metal fuel in the Hot Fuel Examination Facility-South. Special emphasis will be given to those aspects of the metal fuel cycle that make the liquid metal reactor especially well-suited to consume the long-lived radioactive actinide elements present in spent reactor fuel. Although the pace of some activities may be adjusted, the overall objectives and content of this program remain unchanged. Final staffing decisions, however, will be made by the Laboratory based upon the total resources available from all program sponsors.

At the Oak Ridge National Laboratory, the advanced instrumentation and control development program and the university research program in robotics, at $3 million each, are not funded in fiscal year 1990. With an overall increase in Department funding for Oak Ridge National Laboratory in fiscal year 1990, it is not expected that an adverse impact on staffing will result from the decision to discontinue funding on advanced controls test operation and robotics activities. Note, however, that Oak Ridge National Laboratory provides coordination support to the robotics program, which is primarily carried out by four universities. It is expected that the reduction in robotics research dollars will affect approximately 11 students and faculty at each of the universities.

At the Energy Technology Engineering Center, approximately $0.5 million in the seismic testing programs were not funded in the fiscal year 1990 budget. The seismic activities were essentially carried out by various universities and no Energy Technology Engineering Center employees impacts should occur.

In the case of the modular high temperature gas reactor program, the $15 million request for fiscal year 1990 represents a $5 million reduction from fiscal year 1989. Fiscal year 1990 Department funding is expected to be augmented by private sector cost sharing. It is also expected that high temperature gas reactor contractors will benefit from common development efforts in the New Production Reactor program. This level of funding will be sufficient to achieve a key fiscal year 1990 milestone, the submission of a Preliminary Safety Analysis Report to the Nuclear Regulatory Commission. Therefore, no adverse personnel impact is anticipated.

In the case of the liquid metal reactor design program, $4 million is requested in fiscal year 1990. This represents a $10 million reduction from fiscal year 1989. Some of the reduction results from the recent selection of the General Electric Power Reactor Inherently Safe Module as the reference plant design for future development. In addition, it is anticipated that funding available through international collaborative agreements and/or private sector cost sharing will supplement the requested fiscal year 1990 funds to enable the highest priority Power Reactor Inherently Safe Module design work to continue. A draft advanced conceptual design description and a preliminary safety and information document will be completed in fiscal year 1990. The greatest personnel staffing impacts are anticipated at the contractors who have teamed with General Electric to provide design, fabricability, module transportation and field assembly support activities.

Ms. NOVAK. All of us, I'm sure, every person in this room, is involved in some way or another in believing that nuclear energy provides its own unique benefits and contributions in many different forms. Here we're talking a great deal about electricity, but some of our programs, as you well know, go beyond just electricity production.

I don't think there is any question that we're all moving towards that and going, sometimes it seems, very slow. There are often legitimate reasons. We have to be very careful with the technology and how we develop it. We have to weigh the benefits of this program against other programs, for example, in the Department of Energy, as you well have to do up here in looking at your authorizations and appropriations.

But I don't think anyone would agree with you here that if we had our druthers we would rather move a lot faster on a lot more fronts than we're doing right now.

Mr. FAWELL. And I empathize with that answer, too. I felt that when we had the long hot summer and the drought and so forth and so on—there is an old story about the politician who changed his mind and they said, "I'm glad to see you saw the light." And he says, "Not light. I felt the heat."

When we felt the heat last summer, I thought there might be some real movement, but it just seems to me to be more of the same, but less. We are simply not taking seriously and not doing the hard prioritizing, even if we were to pick just one of these alternative energy sources, zero in on—to show I'm not just partial toward the Integral Fast Reactor, but hydrogen and—we talk about waiting until it's cost-efficient, and yet I don't know how many people we're killing by all the continued reliance heavily—and I know my friend from Texas, I told him I was going to say this—and the over-reliance on fossil fuels. We seem comfortable in killing people with fossil fuel emissions because we've done it since the cave men days, and we aren't any advanced, really, except we just do a lot more of it.

But now we may be screwing up this good earth also. And then when I look at nothing but cutbacks, it doesn't seem to me we're doing the prioritizing we ought to be doing. It's my understanding that the $6.1 million proposed to be spent on the Metal Fuel Program probably wouldn't be enough to pay for the termination costs, people tell me. And I am a layman on the subject.

How can you justify that?

Ms. NOVAK. I could only answer by saying that if you look beneath the surface on most of our facilities and programs there, that the termination costs in many of the contracts with facilities and things we have are so enormous that we probably couldn't afford to pay, in current budget regimes, for any of the terminations.

Mr. FAWELL. But you can't afford to close them.

Ms. NOVAK. It's not only applicable in the IFR, and I don't know the particular termination costs that would be involved in that one, but I have looked at some of the other facilities, and I'm telling you we can't afford to close them down.

Mr. FAWELL. Thank you very much.

Mr. STALLINGS. Mr. Schiff.

Mr. SCHIFF. Thank you, Mr. Chairman.

Very briefly, two things. First an observation. Though I represent New Mexico as part of the Southwest, I was born and raised in Illinois, as Congressman Fawell knows, and a whole bunch of high sulfur coal comes out of Illinois. No reason to look at us on that one, Congressman.

I have one question, Ms. Novak, please. I am a new Member of the Congress and this Committee and this Subcommittee. The concern I have is a general one. I've asked it to other people testifying in other forums of energy research.

I'm just wondering if the emphasis on such matters as the Manned Space Station and the Superconducting Super-Collider, both of which I approve of individually, but I wonder if the financial emphasis on those programs in your judgment is interfering with the areas of energy research for which you are responsible, specifically nuclear engineering research and so forth. If there is an interference with funding, in other words, because we're going in those directions. Are we not able to get into as much as you feel ought to be done in this direction is what I'm asking.

Ms. NOVAK. I think that if I had to be concerned about other programs that may affect the funding levels for nuclear energy, I don't think those particular things would be ones that I would be concerned about. I mean I think that they would be going on irrespective of what our dollar amounts would be, or would be looked at, or programs similar to them in basic energy and long-term research.

So the fact that they are large, visible, and expensive projects doesn't as much concern me as the fact that in general and realistically it's mostly the accumulation of many, many other small pieces in other programs, in other little areas, that in the real world end up being the pressure points on a program area like nuclear energy, and I'm sure that is true for many of the other program areas in the Department of Energy, for example. It tends not to be the larger ones.

Mr. SCHIFF. I just wanted to observe, Mr. Chairman, I think well of the other programs and just wanted to hear from the witnesses whether there was any interference in existing programs from those highly visible programs.

Thank you very much.

Mr. STALLINGS. Madam Chairman, would you have additional questions you would like to pursue?

Mrs. LLOYD. No, thank you.

Mr. STALLINGS. Mr. Morrison, do you have anything else you would like to ask?

Mr. MORRISON. No, thank you.

Mr. STALLINGS. Ms. Novak, we certainly appreciate your testimony and your responses to the questions. I know it must be frustrating in this world of uncertainties, but we think you have done a good job and we appreciate your efforts.

Mrs. LLOYD. Thank you very much, Mr. Stallings. I certainly appreciate the attendance of our conscientious and our knowledgeable Members of this panel.

Our first three witnesses—pardon me. We're getting ahead of ourselves. Our second witness is Mr. Victor Stello, Executive Director for Operations for the U.S. Nuclear Regulatory Commission.

Mr. Stello, good to have you with us today.

Mr. STELLO. With your permission, Madam Chairman, I've asked other members from the staff to join me to be able to respond to your questions as fully as we can.

Mrs. LLOYD. We are delighted to have all of you here. Would you please identify your associates?

STATEMENT OF VICTOR STELLO, JR., EXECUTIVE DIRECTOR FOR OPERATIONS, U.S. NUCLEAR REGULATORY COMMISSION, ACCOMPANIED BY ROBERT BERNERO, DIRECTOR, OFFICE OF NUCLEAR MATERIALS SAFETY AND SAFEGUARDS; THOMAS KING, CHIEF, ADVANCED REACTOR AND GENERIC ISSUES BRANCH, OFFICE OF NUCLEAR REGULATORY RESEARCH; AND LES RUBINSTEIN, ASSISTANT DIRECTOR FOR REGION IV REACTORS AND SPECIAL PROJECTS, OFFICE OF NRR

Mr. STELLO. On my left is Robert Bernero, who is the Director of the Office of Nuclear Materials and Safeguards. On my right is Tom King, who is the Chief of the Advanced Reactor Branch in Research. On his right is Les Rubinstein who is the Assistant Director for Special Projects in our Office of NRR.

With your permission also, I would like if my testimony could be entered into the record as if read.

Mrs. LLOYD. Without objection, it will be inserted in the record in its entirety and you may summarize or proceed as you wish.

Mr. STELLO. In light of the testimony you've heard thus far, I think I would like to add a few comments to the testimony, I thihk, that would help shed some light on some issues.

The first is to correct my testimony. I indicated in the testimony that the MHTGR SER would be issued in a few days and that a letter to DOE would be sent also in a few days. The Subcommittee was provided with copies of both the SER and the letter this morning. We had issued it yesterday so that we have done something ahead of schedule. That was a pleasant surprise to me.

Mrs. LLOYD. Congratulations.

Mr. STELLO. The two additional points that I think are worth making, deal with the issue, standardization and certification. This is an issue which the Commission has spent considerable time and effort in recognizing that we needed to provide a regulatory framework which would be stable in the eyes of the industry in terms of a licensing process.

The Commission has before it now and hopefully will be deciding in the next few days, or perhaps weeks, to promulgate a new regulation, Part 52 of our regulations, which will set forth the process by which plants can be certified. The ideal of this particular regulation is to set forth the framework where, in the future, there would be certified plants, certified in the regulations, that if a particular applicant were to choose he could, in combination with a pre-approved site, go to a one-step licensing process and be issued a permit both to construct and hopefully operate the plant with only one hearing necessary for that purpose.

It is the view of the staff that this particular regulation goes as far as we can within the authority we have under the Atomic Energy Act, and the Commission has indicated that it will reflect when it finishes its review and makes a decision on that rule, and there is an expectation perhaps that they will ask Congress to pass some additional legislation to deal with this issue, and hopefully that would be forthcoming then in the near future as well.

I am pleased with the progress that we have made in what I believe is a very, very important subject in terms of really achieving a licensing reform to deal with how to go forward with licensing new plants. I believe it has many, many advantages to offer both to the regulatory process, to the industry we regulate, and hopefully that will be also of benefit to the American people in the end.

The other point that I wanted to make was with respect to advanced reactors. The Commission has issued a policy statement which strongly encourages the industry to develop reactor concepts without the notion or idea that they are constrained to follow the existing framework of regulation, but rather free with the ingenuity of the designers to look at what kind of designs can be forthcoming for which significant advances in safety might be made.

I wish to speak specifically to the issue that this goes directly to the advanced reactors that are now before us, as proposed by DOE, and deal directly with the issue of containment which we have raised in the letter that was sent to Ms. Novak this morning.

The whole idea is to allow that innovation so that if a reactor can be made safer, and that safety is in fact achieved by not having the usual kind of a containment system, that that freedom is there and is encouraged. Of course, we want to see the full justification for whatever that design might be—and that's the thrust of the issue—to make sure that we are persuaded those designs go forward.

Madam Chairman, with those two brief comments, we are prepared to answer any further questions you may have. I would note that we also have included in the testimony at your request, our program on Spent Fuel Storage, and we are prepared to answer questions related to any of the issues raised in our testimony.

[The complete statement of Mr. Stello follows:]

PREPARED TESTIMONY

SUBMITTED BY

UNITED STATES NUCLEAR REGULATORY COMMISSION

PRESENTED BY

VICTOR STELLO, JR.

EXECUTIVE DIRECTOR FOR OPERATIONS

TO THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

UNITED STATES HOUSE OF REPRESENTATIVES

CONCERNING NRC'S ACTIVITIES ON

ADVANCED REACTORS

PROPOSED BY THE DEPARTMENT OF ENERGY

AND

SPENT FUEL STORAGE

Thank you Madam Chairman. I am pleased to appear before you and members of your Subcommittee today to discuss the Nuclear Regulatory Commission's (NRC) activities on the different types of advanced reactors sponsored by the Department of Energy (DOE) and on the NRC's spent fuel storage program. Other members of the NRC staff involved in this work are with me today. I will begin by identifying and summarizing the review status of the various advanced reactor types. This summary will include our safety expectations for these reactors. I will then proceed to discuss, in more detail, the status of the non-light water advanced reactors, with emphasis on the Modular High Temperature Gas-Cooled Reactor (MHTGR), because these reviews are nearing completion. I will conclude my testimony with a summary of the NRC's spent fuel storage program.

Summary of Review Status

We currently consider advanced reactors to fall into three categories; evolutionary light-water reactors (LWRs), advanced non-LWR designs, and small passive LWRs. The specific designs that we have under review, or anticipate to review, in each of these three categories are identified in Table I attached to this statement. All of these designs, except the Westinghouse SP/90 evolutionary LWR design, have, some degree of financial support from DOE.

All of our reviews are, or ultimately will be, standard plant reviews with design certification as the objective. The schedule for our review processes is identified in Table 1. This includes estimated dates, if available, for preliminary design approvals (PDAs), final design approvals (FDAs) and the design certification hearing. For the evolutionary LWRs, our technical reviews

Non-LWR Advanced Reactors

are in progress and should be completed in the 1990-1992 time frame. For the advanced non-LWRs, technical reviews of the conceptual designs including review by the Advisory Committee on Reactor Safeguards (ACRS), and the drafting of our Safety Evaluation Reports (SERs) have been completed. Issuance of final SERs is contingent upon receipt from DOE of additional information on containment.

Comparative Safety Expectations

Although we are not comparing one reactor design against another, we can qualitatively see the potential for enhanced safety in each succeeding generation of designs. Accordingly, the evolutionary LWRs are expected to achieve an enhanced level of safety over existing LWRs by incorporating evolutionary design improvements (for example, implementation of lessons learned), addressing severe accident issues at the design stage, and standardization. The small passive LWRs are expected to achieve a more enhanced level of safety by utilizing simplified and passive safety features and reducing the potential for severe accidents. Likewise, the advanced non-LWRs are expected to have an even greater level of safety through utilization of more advanced technologies such as high temperature fuel, improved heat transfer and use of simplified and passive safety features. These technologies are all directed toward preventing severe accidents and significant releases of radioactive material and demonstrating the capability to withstand severe challenges.

The emphasis of this portion of my presentation will be on the non-LWR advanced designs and, in particular, the MHTGR because it is the first of these advanced non-LWR designs to have undergone our review. I will begin by summarizing the activities that have occurred since I last testified before this Subcommittee, and then proceed to address the containment adequacy issue. Finally, I will summarize the results of the MHTGR technical review and the context in which the staff's review should be viewed.

Recent Accomplishments

In early June 1988, the staff completed a draft SER for the MHTGR and submitted it for review by the ACRS. In this draft SER, the staff concluded that the MHTGR, as generally conceived, was responsive to the Commission's Advanced Reactor Policy Statement. Further, the staff stated, subject to satisfactory resolution of the identified open issues, that the MHTGR has the potential to achieve a level of safety at least equivalent to that of the current generation of LWRs and, in some areas, has the potential to provide enhanced safety beyond those in the current generation of LWRs. This is of course contingent upon resolution of the open items and completion of an extensive research and development program, including prototype testing. These and other issues are discussed in detail in the draft SER for the MHTGR.

After a series of meetings conducted by the ACRS Subcommittee on Advanced Reactors and the full ACRS, the ACRS reported to Chairman Zech in an October 13, 1988 letter that it was in general agreement that design and development should continue along the lines outlined by the NRC staff and that research and development could resolve important safety issues before licensing. In addition, the ACRS provided a number of comments on the design. ACRS letter reports were issued on November 22, 1988, and January 19, 1989, for the PRISM and SAFR liquid metal reactors, respectively. These reports were, in general, similar to the MHTGR letter report.

Containment Adequacy Issue

The inclusion of reactor containment buildings in LWR designs has been a longstanding NRC requirement to provide defense in depth protection against releases of radioactivity in case of accidents. Although the MHTGR concept shows promise of significantly enhanced safety, it will nevertheless be very difficult for the NRC to allow modification of what is currently considered a fundamental element of safety without a compelling rationale from DOE.

In August 1988, we became aware of DOE's recommendation to Congress that a version of the MHTGR concept be developed as one of the new production reactors (NPR). It was our understanding that the NPR - MHTGR would have many similarities to the commercial MHTGR, but, in addition, would employ a containment structure not proposed to the NRC for the commercial version. In order to clarify this issue, I requested in a letter to DOE dated August 17, 1988, that the Department provide its rationale for this apparent inconsistency. The Department responded in September 1988; however, through further communication with DOE, it became clear that additional information was required to resolve this issue. It is our understanding that the Department plans to provide this additional information in June 1989. If this information resolves our concerns, we will prepare the SER in final form and forward it to the Commissioners for review, approval and issuance as a final document. Final

Commission action on this document is not expected to occur until the end of FY 1989.

In the interim, the Commission has approved issuance by the staff of an incomplete (draft) SER for the MHTGR. The draft SER contains the results of the staff's technical evaluation and insights to date, and would be issued primarily to assist DOE and its contractors in the further development of the MHTGR concept. The draft SERs for the liquid metal reactors will be issued in a similar fashion, when ready. In issuing these draft SERs, appropriate cautions have been included regarding their draft nature and use, including the fact that these draft SERs do not at present represent a final Commission position.

Madam Chairman, I want to place special emphasis on the importance of DOE's reply on this major policy issue. We have suggested that DOE ask the Energy Research Advisory Board, which reviewed the production reactor concepts, to consider the issue and provide its advice to DOE. I will soon be writing to emphasize to DOE that the Commission would need a thorough and detailed justification to support any design proposal that does not include a containment structure.

Summary of MHTGR Review

The staff's review and evaluation of the MHTGR concept has emphasized the identification and assessment of those technical features and characteristics of the MHTGR design having major bearing on the acceptability of the design.

The staff believes that the MHTGR has many favorable characteristics. However, the final determination of the acceptability of the design is contingent on the following:

(1) satisfactory resolution of the policy issues associated with the design, including the containment adequacy issue as discussed above.

(2) satisfactory resolution of the open safety issues identified in the draft SER and possible additional safety issues that may become identified at later stages of review.

(3) satisfactory completion of final design and licensing reviews by NRC.

(4) satisfactory completion of research and development activities, including successful design, construction, testing, and operation of a prototype reactor.

Integral Fast Reactor (IFR) Concept

To date, we have not been requested to review DOE's IFR concept, although our review of the PRISM and SAFR liquid metal reactor (LMR) designs coupled with a planned scoping study on the LMR fuel cycle (to be completed in fiscal year 1990), should address many of the safety issues associated with this concept.

Summary of Advanced Reactors

In summary, I believe that our advanced reactor reviews are progressing and are consistent with industry needs. It has taken somewhat longer than originally planned to complete the reviews of the advanced non-LWR designs. This is in part due to the fundamental nature of the safety issues associated with these designs and the need to clearly understand DOE's position and rationale on containment.

Spent Fuel Storage

Next, I would like to discuss spent fuel storage with particular emphasis on dry spent fuel storage. Since the 1970's there has been concern over the accumulation of spent fuel in storage pending disposal in a high-level waste repository. The Nuclear Waste Policy Act (NWPA) of 1982 in Sections 133 and 218(a), directed the Commission to develop, to the maximum extent practicable, non-site-specific rulemaking for dry storage technologies. In Section 218(a), the NPWA provided for DOE to perform spent fuel storage research and development and, in concert with utilities, to cooperate in NRC licensed spent fuel storage demonstrations to further assist NRC in developing the regulatory process for spent fuel storage. DOE has been carrying out its mandate by performing basic research and development and demonstrations of dry storage. DOE entered into two cooperative agreements to assist in dry storage demonstrations at Virginia Power's Surry Power Station in Surry County, Virginia, and Carolina Power and Light Company's H. B. Robinson Steam Electric

Plant, Unit 2, site in Darlington County, South Carolina. DOE's efforts have provided a valuable base of data and storage experience that has facilitated NRC's reviews of dry storage technology designs and license applications, and NRC's rulemaking effort.

With respect to dry spent fuel storage, I would like to emphasize that the NRC has had regulations in place governing such storage since November 1980. 10 CFR Part 72 covers a variety of storage technologies, including dry storage in metal and concrete casks and concrete modules and vaults. We are continuing to develop new regulations, as directed by Congress in the NWPA, to address non-site-specific approval of dry storage. We have licensed dry storage at two nuclear power plant sites, are reviewing an application for a third plant site, and expect several more applications this year.

NRC has developed a substantial base of licensing experience. As one avenue to simplify the site-specific licensing process in existing regulations, NRC staff have reviewed topical safety analysis reports for a variety of dry storage technologies. Such reports avoid the need for repeating staff safety reviews of approved designs in each license review. Reports for four cask designs, a concrete module and stainless steel canister system design, and a modular concrete vault design have been approved. In 1986 the Commission issued licenses for dry spent fuel cask storage at Surry and for concrete module storage at H. B. Robinson. With two designs approved in licensing actions and others that have been reviewed and accepted in topical reports by the staff, the nuclear utility industry has a variety of dry storage designs available to it to meet potential storage capacity shortfalls. (See attached Table 2 for reports approved and under review, licenses approved, and license applications received.)

Making use of the data and experience provided by DOE, combined with safety and environmental review and licensing experience developed at NRC with respect to dry spent fuel storage, NRC staff is preparing a proposed rulemaking. This proposed rulemaking would establish regulations for a general license to operating power reactor licensees to use pre-approved dry spent fuel storage casks at their reactor sites. Thus, for casks which have been reviewed and certified by the Commission, licensees that meet the conditions and limitations of the general license would simply register as certified cask users. No site-specific license under Part 72 would be required for storage of spent fuel in certified casks at a reactor site. No Part 50 license amendment would be required unless the handling or storage of the casks involved a license change, a change in plant technical specifications, or an unreviewed safety question. NRC staff will also explore extending its non-site-specific rulemaking efforts from casks to other types of modular dry storage, such as concrete modules, in subsequent rulemaking.

I would like to emphasize that NRC believes there is a continuing role for both DOE and industry to further optimize the dry spent fuel storage option through research and technology development. DOE is beginning to address other technical barriers to further economy in dry storage. These include calculational and measurement methodologies for reactivity that may enable increased spent fuel loading per cask. Achievement of this objective involves taking into account the reduction in the ability of fuel to achieve a critical reaction as it is used in a reactor.

Also, in concert with the industry, DOE is seeking to increase efficiency in fuel management by avoiding excess fuel handling in the storage and transportation system. NRC supports DOE's efforts in storage and transportation development to ensure compatibility of various steps in the storage, transport and disposal of spent fuel to enhance the safety and efficiency of fuel handling. NRC will continue to encourage DOE and industry coordination on this objective.

In summary, a variety of dry storage design solutions exist for nuclear utilities to meet potential spent fuel storage capacity shortfalls. A variety of licensing mechanisms exist and are under development to ensure that dry storage is a readily available option to meet utility needs. Continuing work on the part of DOE, vendors, and the utilities, as well as continuing efforts on the part of NRC to facilitate the licensing process, will enhance the timeliness and cost effectiveness of dry spent fuel storage.

This concludes my prepared testimony and I will be happy to answer any questions you or the members of your Subcommittee may have.

Table I

Identification of Advanced Reactor Types

Reactor	Lead Industry Developer	Power Level, Mwe	Schedule, Remarks
Evolutionary Light Water Reactors (LWRs)			
Advanced Boiling Water Reactor (ABWR)	General Electric	1300	FDA - 7/90 Certification - 8/90 - 8/91
Standard Plant for the '90s (SP/90)	Westinghouse	1300	PDA - 10/89 FDA - 1/92
System 80 Plus	Combustion Engineering	1300	FDA - 4/91 Certification - 5/91 - 10/92
Advanced LWR Requirements Document	Electric Power Research Institute	-	SER - 9/90
Advanced Non-LWR Designs			
Modular High Temperature Gas-Cooled Reactor (MHTGR)	General Atomics	540 (4 units)	PDA - 1992*
Power Reactor Inherently Safe Module (PRISM)	General Electric	1245 (9 units)	PDA - 1994*
Sodium Advanced Fast Reactor (SAFR)	Rockwell International	1400 (4 units)	Design Merged into PRISM

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* - Based upon projected schedules provided by DOE.

Small Passive LWRs	Industry Lead	Power Level, Mwe	Schedule, Remarks
Advanced Passive (AP) - 600	Westinghouse	600	Conceptual Design to be Submitted in March
Simplified Boiling Water Reactor (SBWR)	General Electric	600	Not yet scheduled

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PDA - Preliminary Design Approval
FDA - Final Design Approval

Table 2

STATUS OF DRY SPENT FUEL STORAGE LICENSING

Topical Reports Approved

TYPE	VENDOR	MODEL	CAPACITY (Assemblies)	DATE OF NRC STAFF APPROVAL
Metal Cask	General Nuclear Systems, Inc.	CASTOR V/21	21 PWR	9/85
Concrete Module	NUTECH, Inc.	NUHOMS	7 PWR	3/86
Metal Cask	Westinghouse	MC-10	24 PWR	9/87
Metal Cask	Nuclear Assurance Corporation	S/T	26 PWR	3/88
Concrete Vault	FW Energy Applications, Inc.	Modular Vault Dry Store	83 PWR or 150 BWR	3/88
Metal Cask	Nuclear Assurance Corporation	NAC-C28 S/T	28 canisters (for fuel rods from 56 PWR assemblies)	9/88

Topical Reports Under Review

TYPE	VENDOR	MODEL	CAPACITY (Assemblies)
Metal Cask	Combustion Engineering	Dry Cap	24 PWR or 60 BWR
Metal Cask	Transnuclear	TN-24	24 PWR
Concrete Cask	Pacific Sierra Nuclear Associates	CP-9	9 PWR
Concrete Module	NUTECH, Inc.	NUHOMS-24P	24 PWR
Metal Cask	General Nuclear Systems, Inc.	CASTOR X	28 PWR or 33 PWR
Metal Cask	Nuclear Assurance Corporation	NAC-31 S/T	31 PWR
Metal Cask	Nuclear Assurance Corporation	NAC-I28 S/T	28 PWR

Licenses Issued

UTILITY	REACTOR SITE	DOCKET AND LICENSE NOS.	DATE OF ISSUANCE
Virginia Electric and Power Co.	Surry Power Station (Surry County, Virginia)	72-2; SNM-2501	7/86
Carolina Power and Light Co.	H. B. Robinsion Steam Electric Plant, Unit 2 (Darlington Co., South Carolina)	72-3; SNM-2502	8/86

License Application Received

UTILITY	REACTOR SITE	DOCKET NO.	DATE OF RECEIPT
Duke Power Co.	Oconee Nuclear Station	72-4	3/87 (Environmental Assessment and Finding of No Significant Impact issued 10/88)

DISCUSSION

Mrs. LLOYD. Thank you very much, Mr. Stello. Turning to the LWRs, in terms of establishing the NRC process for certification of new power plant designs, is it really beneficial to conduct a certification program on the Pressurized Water Reactor and the Boiling Water Reactor? Wouldn't one reactor serve to establish and demonstrate the certification process? I'm a little bit puzzled with this.

Mr. STELLO. In my view, any reactor that the industry would use in the future, it is my fond hope that those would all be a result of going through the certification process. So we would hope that all of them would eventually go through the certification process.

However, many might be useful to demonstrate to the industry's satisfaction that that particular process is viable and useful and amenable. I don't know that I can make that kind of judgment for the industry. I am selfish in looking at it from my point of view. The more experience we have with the process and the earlier we have that experience I see as a greater benefit as regulators, it would be more beneficial to us.

Mrs. LLOYD. Do you feel that it's beneficial to both the industry as well as the designers?

Mr. STELLO. I think you need to ask the industry. It is my view it is clearly, from the regulatory point of view, the more experience we can get with this, the better we are.

Mrs. LLOYD. You feel there are lessons learned through the certification process.

Mr. STELLO. Clearly. There is going to be a lot of new ground to cover as we go through it, and we are going to be learning a lot of lessons. The sooner we learn them, the better off we are.

Mrs. LLOYD. The NRC I believe has asked Combustion as well as General Electric to submit a full-scope design on their evolutionary plants before you will go further with their certification on their concepts.

Was this something that they should have anticipated in their design that you had asked for some information?

Mr. STELLO. There has been considerable debate over the years as to how to proceed. The Nuclear Regulatory Commission has been taking the position that the most benefit out of a certified standardized design, overall benefit to the entire industry as well as regulation, is for a full-scope standardized design to be certified.

Mrs. LLOYD. Let me ask you this way. What are the advantages of having a plant certified by the NRC?

Mr. STELLO. From the point of view of issues that get raised of what challenges might come to the plant, because of the design of the balance of plant system, immediately come on the table and are resolved, and that particular issue is put to bed, then once and for all——

Mrs. LLOYD. You think it dissipates environmental concerns?

Mr. STELLO. Not as much environmental as the impact on the safety systems and the challenges to the safety systems——

Mrs. LLOYD. On the engineering system.

Mr. STELLO [continuing]. On the nuclear steam supply side. I think in terms of benefit to the industry, then they have a full plant that is certified that they can go forward with, for which we've done the entire review of the facility except for transmission lines and heat sinks, things that it is not possible to do that are more site-specific than they are design-specific.

Mrs. **Lloyd**. I want you to comment on the rationale on the NPR because it will have a significantly different core; that a containment building is a prudent precaution.

Mr. **Stello**. I don't think it's just simply because the core is different. I would start with—the two designs have a great deal of similarity, and it is difficult to understand why one is different in such a context for which a containment system of some type might be desirable and not in the others.

The Department of Energy has agreed that they are continuing to do those studies and will make them available to us in June of this year. I don't mean by that, however, to suggest that the civilian MHTGR needs to have the same kind of confinement or containment system, whatever it is that they finally decide on in the NPR on the civilian. It's not making a judgment that that is in fact what is required, but rather to be fully satisfied that if one is not provided, that we have that full, complete, technical basis and understanding for why not.

Mrs. **Lloyd**. What is the NRC's position on existing plant life extension? What facilities have contacted you regarding plant life extension? Who do you expect to be the first application for the extension?

Mr. **Stello**. I don't know which the first one might be, but I think Yankee Row and Monticello are—they're both expected to come in in 1991. The one who I understand might be first is Yankee Row. There are, of course, a number of other utilities who have indicated a deep interest in this matter as you might expect.

Mrs. **Lloyd**. What is the NRC position on life extension?

Mr. **Stello**. We believe that life extension is clearly viable. There are technical issues that we need to address and resolve, but I also believe that that's going to be a fairly substantial issue for the Agency, and I think we're going to get a fairly large workload out of it.

As you look at the industry today, which has probably invested nearly a half a trillion dollars in nuclear facilities, that's a rather substantial capital investment and there is no fundamental technical reason why they can't be used beyond 40 years. And I suspect that there is going to be a great deal of interest, and what I have heard from the industry is that that indeed is true, that there will be many licensees who want to operate those plants beyond 40 years and no fundamental technical reason why they cannot be.

If they are adequately maintained and the right issues are raised and resolved, technically we can deal with it without too much difficulty. What we need to be mindful of is making sure that we have put the licensing process in place to deal with that and we are now working on that very issue to make sure that we have a licensing basis to allow that to be accomplished in as efficient a manner as we know how.

Mrs. **Lloyd**. Thank you.

Mr. Morrison?

Mr. **Morrison**. Thank you, Madam Chairman.

It is my major concern in discussions with NRC as we look at Committee jurisdiction, in fact, just to make sure that the track that we are on the research and development area is one that tracks with the bureaucratic aspects of the nuclear business.

You mentioned that you, the Commission itself may be coming to Congress asking for additional flexibility as far as your authority is concerned?

Mr. STELLO. The specific issue I have in mind on legislation is to deal with the one-step licensing process. The Atomic Energy Act at the moment, as I understand it, requires and mandates that we will have a hearing whether one is requested or not, at the construction permit stage when an application to build a plant is filed.

There is then an additional hearing which can be held prior to issuing an operating license when there is a request to do so. It is not mandatory whenever there is a request. That creates a great deal of concern for the industry, as clearly the record does show, understandably so, where a plant can be constructed and built and then sit there for a very, very long time while the issues are resolved during a hearing at the operating license stage.

To get the single hearing issue, for us to have the authority to clearly and unambiguously do that, it is my understanding that that would require legislation.

Mr. MORRISON. We will be most interested in helping in any way that we can. I think this Subcommittee looks at its responsibility and believes that we're on the right track, maybe with not enough funding, but that we're on the right track as far as evolutionary development and even revolutionary development of energy sources.

And I just want to make sure that we're on the same track that you're on as far as your planning procedures are concerned.

In that light, we're in sort of a dry spell now. No one is ordering new plants. No one is building really much. Do you anticipate that you've looked at everything that's coming down the road?

Ms. Novak was here describing the move toward pre-approval, toward modular plants, attempting to shorten that time frame for investment for utilities. Do you sense NRC is doing everything that you can during this quiet time, if I could describe it that way, so that we could be ready to make nuclear one of the viable parts of America's energy mix?

Mr. STELLO. I feel comfortable that the Agency is moving to establish a licensing framework that I believe is necessary, at least one of the elements necessary—to be responsive to your question—which is, to say it simply, is so that any particular utility that wishes to build a plant will know that that plant has in fact been certified because it will be in our regulation, and it is approved to go forward with both construction and operation.

In a one-step licensing hearing, we are allowing for the sites to be pre-approved, so that the utility will know that both the plant is pre-approved, the site is pre-approved. He could put the site and the plant together to deal with then the site-specific issues and get rid of as many, if not all, of the issues which can be a problem in getting the licensing issue resolved, prior to him ever beginning the construction of a facility.

I think that that's going to be a very, very important step. We've done that. If, on the other hand, there is going to be a need or a desire for the utilities to request a construction permit and operating license without using this new procedure I've talked about, going through what I refer to as our custom review process, I have asked to have that particular issue looked at and just yesterday got a report from a group looking at that subject of are we really ready to do what I will call a custom-review process.

I think we need to look at that particular issue to make sure that we're comfortable in being ready to take on those kinds of reviews because it is my belief that the option is there, and if the demand for electricity and the need for additional generating capacity becomes acute, there may be a desire to go to a custom plant licensing process that is using procedures of today. And if we are to do that, we need to get ready, and we're looking at that now.

Mr. MORRISON. What sort of a timetable might be involved if all of these pieces fell into place, from the utility ordering a plant, to being on line?

Mr. STELLO. I would think it could be, with pre-approved sites and a certified plant, I don't know of any reason it can't be down in the range of five years. We've already had one that was constructed in under five years, so the bulk of the review and licensing process should have taken place before then, so some period of time, five or six years, would seem certainly possible to me.

Mr. MORRISON. It's not only possible. I think it's highly desirable. I think it will be the key, very frankly, to getting nuclear back into our energy swing.

Mr. STELLO. The key, I think is the need for one-step licensing process. The two-stage licensing process, as you know from the plants you've heard a great deal about, can take a long, long time.

Mr. MORRISON. Thank you very much.

Mrs. LLOYD. Thank you, Mr. Morrison.

Mr. Fawell?

Mr. FAWELL. Thank you, Madam Chairman. I will state that I will submit written questions to Mr. Stello. Time is a problem which I have, and I must leave, and reluctantly will not have the honor of introducing Dr. Yoon Chang who is a member of the next panel, but I am sure you will be as impressed of him as we are at Argonne Lab. And I'm sorry I do have to rush off.

Mrs. LLOYD. That will qualify for an introduction.

Mr. FAWELL. Yes. I think it's a sneaky way to have done it.

Mrs. LLOYD. I think the next panel is going to be pretty well represented. It's going to be all old home week. We have Dr. Jones from Oak Ridge whom I certainly want to welcome today; Dr. Yoon Chang is from your district; and Dr. Korenko is from your district, Sid, so I think it will be a very congenial panel today.

Mr. Schiff? You don't have anybody on the next panel.

Mr. SCHIFF. I don't have anyone on the next panel and I have no questions for this panel, for this speaker rather. Thank you very much. I'll be glad to fly someone in from Los Alamos or Sandia, though, if the chair would entertain the motion.

Mrs. LLOYD. Your day will come another day.

Mr. Stello, you mentioned in your remarks that the MHTGR will achieve a level of safety at least equivalent to the LWRs. Now, isn't it true that the NRC has not identified a credible accident scenario for the MHTGR that would lead to an offsite release of radiation that would require public protection?

Mr. **Stello**. I think that's a fair statement but it needs at least one reservation. The information we have to judge the likelihood or frequency or possibility, which is part of risk, is based on a lot of preliminary information on the MHTGR verus a great deal, a considerable volume of information with respect to current operating Light Water Reactors.

But I would also add that I think that the MHTGR has the potential to equal, I should say, or exceed. It is the desire and hope of the Agency in going forward with the advanced reactor policy statement that, allowing that kind of innovation would produce designs for which significant improvement in safety is possible, and we see a promise in these designs that that in fact can be achieved.

Mrs. **Lloyd**. Very good. I think that better clarifies the issue.

Do the MHTGR and the LMR designs fully comply with NRC's advanced reactor policy statement?

Mr. **Stello**. Yes. They were progressing along those lines and hopefully if they will continue, it will continue in that same vein.

Mrs. **Lloyd**. Mr. Walker.

Mr. **Walker**. Thank you, Madam Chairman.

First of all, I would like to pass out a kudo. The way you all have handled the situation with Philadelphia Electric has been much appreciated by a number of us who are in that area. That's been a very difficult problem up there. Once again my area of the country is faced with management failures within the industry.

That just leads to a question here. Is there something that we ought to be doing out of this Committee that would assist you in terms of research to deal with some of the human issues that surround the technology? I mean we've had a couple of failures up there, neither of which have been largely technology issues. They've been largely human issues.

Is there some additional research that needs to be done that would address some of those concerns?

Mr. **Stello**. No. All of the research—yes, there is additional need for research, but we don't need—I guess I should be reserved about saying this—we don't need anymore help. If we get our budget for the NRC, we have in our budget what we believe is adequate funds to look into those areas related to the human element which will help us be able to deal with that more effectively.

So the answer is, if we get our budget I'll be very pleased.

Mr. **Walker**. Okay.

What is the nature of the work that you are planning to do?

Mr. **Stello**. Let me do it in a summary fashion and I'll be happy to provide you with the specifics for the record.

Mr. **Walker**. That would be very helpful.

Mrs. **Lloyd**. If you would provide that for the record we would appreciate it.

[The information follows:]

INSERT FOR THE RECORD
HOUSE SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
DOE'S FY 1990 BUDGET REQUEST FOR NUCLEAR FISSION
March 1, 1989

Insert for page 64, line 1547

Because human performance is a causal factor in more than half of all reported events occurring at U.S. nuclear power plants, research is needed to develop better methods, measures, and criteria for further enhancing the human factor in nuclear construction, maintenance, and operations. An interdisciplinary human factors research program is underway at the NRC directed toward these goals. Exploratory and applied research focuses on human factors issues identified by the regulatory offices.

NRC human factors research is taking advantage of expertise from within the agency and from commercial firms, private consultants, universities, the Electric Power Research Institute (EPRI), the utilities and plants, and international organizations investigating human performance in nuclear power operations. NRC research is divided into five interrelated elements to take maximum advantage of available resources, minimize duplication and provide continuity.

Human-System Interface research focuses on next generation equipment which will be used by plant personnel as part of their monitoring and intervening responsibilities, on workspace layout and its habitability due to factors such as temperature, lighting, noise and vibration.

Personnel Subsystem research focuses on performance aids such as training, operating procedures, decision support, shift scheduling, and communications factors believed to significantly influence performance in high reliability system settings especially during abnormal conditions. Organization and Management research focuses on individual, team, management and organizational indicators of performance to explain differences in observed performance and guide regulatory actions.

Both Personnel Performance and Reliability Assessment research focus on means for collecting operational, laboratory and analytic data, managing the collected data, and applying these data in actuarial and probabilistic assessments of individual, team, and organizational performance. Findings and products of the Personnel Performance elements, primarily actuarial, provide direct support to NRC licensing, inspection and enforcement activities. Findings and products of the Reliability Assessment element provide direct support to probabilistic risk assessments of plants, which in turn support regulatory activities.

Mr. **Stello**. Questions that we have in mind cover two areas, broadly speaking: the issue of management and management performance. Is there a way in which we could look at various kinds of indicators which would tell us that there are particular problems in management and, if so, what are they and how do you develop them and how do you use them?

On the other side of the spectrum is that we have now a very, very considerable amount of experience in terms of the way in which equipment maloperates or fails and what the reasons are as they relate to the human element. Where is it that a technician or an operator failed to understand something or did something that was incorrect, and how can you take that information, that experience, and start to factor that into the process of getting the changes in training and procedures? How do you go about distilling from the now rather enormous volumes of information to deal with that issue?

Our program is aimed at, from the very detailed application of the information we've accumulated to the rather esoteric area of trying to understand what we can do to understand better management issues.

Now, within the Agency, we've done a great deal directed at that very issue to try to identify plants where there are particular problems in the plants early, so we don't have to go and take the rather dramatic action that we had to take in the case of Peach Bottom.

Mr. **Walker**. Since ultimately you are going to be the regulators, are you taking a look at the questions of how the human element will either be exacerbated or mitigated by the use of modular plants versus custom-built plants?

Mr. **Stello**. That is one of the very significant advantages of these designs is the reliance on the human element is much, much less—a very significant advantage, I might add.

Mr. **Walker**. And more standardized training and so on can be done in that kind of plant.

Mr. **Stello**. Those are the things that we have learned are very, very important and very, very significant and it's one of the very, very important lessons of standardization.

Mr. **Walker**. Thank you, Madam Chairman.

Mr. **Morrison**. Would the gentleman yield before he turns in his time, because it relates directly.

Mr. **Walker**. I would be glad to yield to the gentleman.

Mr. **Morrison**. I've been in communication with a number of researchers who point out that it's not the nuclear furnace that's ever failed. It's either the human element, as my leader Mr. Walker has described, or it's some fairly common components like valves, solenoids, a host of things that are universal parts throughout our industrial arena that have failed.

Does the NRC have a program that might in fact be looking at the fact that we haven't changed valve design for decades or we've not made dramatic improvements that we should in some of the accessory items that are outside the nuclear island?

Mr. **Stello**. We've been putting a great deal of attention on that very question. If you have a moment, what I'd like to do is to tell you what I think I see over the last five years or so in terms of accomplishing that very objective.

Plants today, in my view, are clearly safer. And I think we now have data to show it. You can look at the kinds of things that have created problems: the number of times a plant is scrammed, significantly reduced; the number of times safety systems are actuated are down; the number of significant safety events that occur are down; average exposure in a plant is down; the average number of precursors that we have seen are substantially down from 84 to, this year, almost in half, perhaps even a little more.

I think what you also see as a direct result of that is that the net meaning of it is that equipment is breaking less often. The plants are shut down less often, and the plants are operating in fact more reliably.

In terms of the benefit of that, it means that the capacity factors are higher over the past five years, I think about 7 percentage points, and that is a very, very substantial improvement and benefit to the American people and taxpayers and ratepayers.

I think the industry has improved for these very reasons. It's those kinds of things, failing, and causing problems—and we've been doing a great deal to look directly at what the causes of those are, and we've been successful. I think the data now are available to show that the programs we've put in place are dealing directly with the issue you raised, and successfully so.

Mr. **Morrison**. Good. I thank the gentleman for yielding.

Mr. **Walker**. Thank you, Madam Chairman.

Mrs. **Lloyd**. Thank you, Mr. Walker and thank you, Mr. Morrison. Thank you, Mr. Stello, and your associates for being with us today, and we will have questions for you in writing we'd like for you to answer for the record of the hearing today.

I think our panel has been sufficiently introduced. I would like to welcome at this time Dr. Jones, my constituent; Dr. Yoon Chang, Mr. Fawell's constituent; and Dr. Michael Korenko who is Mr. Morrison's constituent.

I believe this is Dr. Chang's first appearance before the Committee. Is that correct? We welcome you.

Dr. Jones, it's good to have you back and you may proceed.

Panel 1

STATEMENT OF DR. JOHN E. JONES, JR., DIRECTOR OF REACTOR PROGRAMS, OAK RIDGE NATIONAL LABORATORY

Dr. **Jones**. Thank you, Madam Chairman. It's a pleasure to be here on behalf of Oak Ridge National Laboratory. I'll submit my written testimony for the record and I'd like to make some summary comments.

Mrs. **Lloyd**. That's very fine.

Dr. **Jones**. Events have a way of changing our perspective, and those of the last several months have provided some important signals. Electric power demand was up 5 percent in 1988, a factor of 2 higher than projected, and shortages resulted in brownouts in several areas of the country. The extended drought focused attention as never before on the environmental concerns of fossil fuel combustion. These events will shape our energy future.

In the 21st century we see a growing demand for electricity, worldwide emphasis on economic competition, and a heightened environmental sensitivity. The key contributors to a resilient U.S. electric energy system for the 21st century must include end use efficiency or conservation; fossil energy, including coal, oil and gas; and nuclear energy. Each of these major contributors has advantages, limitations and uncertainties. Collectively, however, they offer the balance and resilience necessary to assure the energy requirements for a healthy U.S. economy.

Nuclear energy is important to the U.S. both as an energy source and as an export product. We developed nuclear technology, and to date we are the world's largest exporter. However, there is a worldwide revolution in science and technology. If we expect to maintain our preeminence, the civilian reactor program must provide the advanced technology and advanced designs needed for the U.S. to compete.

In spite of this need, Madam Chairman, technology development and advanced concept design account for only $32 million of the $212 million FY 1990 proposed advanced reactor program budget. This is a decrease from $76 million devoted to these same areas, technology development and advanced concept design, in this year, FY-1989, and over $100 million in the recent past.

Madam Chairman, while we realize the budget constraints faced by the Congress, we believe the U.S. has to devote more resources to technology development and advanced concept design, and I am very gratified by the comments that I've heard from the Committee thus far.

This trend in reducing these efforts is an invitation to disaster in a competitive world. Technological progress is the key to our nuclear future. There are two specific technology areas which I would like to call your attention to. These are addressed in more detail in my written testimony.

The first is MHTGR technology. This technology is being pursued aggressively by Japan spending about $60 million a year, plus having made a recent commitment of $700 million to build a high temperature test reactor, and Germany spending about $90 million per year. And, as you know, Germany is marketing the technology in the USSR and in China.

We have a great idea in the MHTGR concept but our failure to implement the technology development plan prepared over two years ago is hurting our competitive position in the world market. While the design assumptions made during the MHTGR conceptual design seem reasonable, they must be validated. Without this validation, we cannot license or build an MHTGR.

This is the purpose for the Technology Development Program for which ORNL has the lead responsibility. This program focuses on fuel performance, fission product behavior, graphite and metals performance, reactor physics, thermohydraulics, and shielding. The Technology Development Plan requires seven years to complete at a cost of about $12 million per year. In each of the last two years, we have pursued less than one-third of the planned effort because of budget constraints. Technology is now the pacing item on a critical path.

A civilian program budget of $35 million is needed to support design, licensing and technology development schedules consistent with the deployment of a first plant by the late 1990s. ORNL believes the civilian program should be fully funded so as to support both commercial and new production reactor applications. Within the civilian program, at least $12 million should be directed specifically to the base technology development effort.

The second technology issue I would like to mention is strategic technologies for Advanced Liquid Metal Reactors. The long-term importance of Liquid Metal Breeder Reactor in providing technology to extend uranium resources is inevitable. Recently the Department of Energy and its contractors have begun to consider the application of liquid metal reactor technology for another possibly nearer term mission, burning the long-lived actinides in nuclear waste.

Strategic technology programs at Oak Ridge National Lab are a small but vital part of the Advanced LMR effort. ORNL plays a strong national role in each of the these technologies over many years and has established an international preeminence in these areas. No funds are provided for strategic technologies in FY-1990 budget recommendation in the areas of advanced controls, ACTO program, advanced instrumentation, or materials and structural design. The shielding experimental program is funded at $1.0 million.

We recommend and request that the Congress support strategic technologies for the Advanced LMR by authorizing an additional $8.0 million to continue work on Advanced Controls ACTO program, and I might note that this program does include addressing the issues related to the human machine interaction, Madam Chairman, that was brought up in an earlier question, to support areas in advanced instrumentation and materials and structural design.

This budget level would maintain critical support for key experienced research staff and allow us to make significant progress in these technologies. The Committee's support is urgently needed to avoid further erosion in our technology base.

Thank you, Madam Chairman.

[The prepared statement of Dr. Jones follows:]

TESTIMONY OF

JOHN E. JONES JR.

DIRECTOR, REACTOR PROGRAMS
OAK RIDGE NATIONAL LABORATORY

ON THE FY-1990 DOE AUTHORIZATION FOR ADVANCED REACTOR PROGRAMS

before the
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

March 1, 1989

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
Operated by
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for the
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TESTIMONY OF

JOHN E. JONES JR.
DIRECTOR, REACTOR PROGRAMS
OAK RIDGE NATIONAL LABORATORY

BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
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March 1, 1989

Events have a way of changing our perspective, and those of the last several months have provided some important signals. Electric power demand was up 5 percent in 1988 (a factor of 2 higher than projected), and shortages resulted in brownouts in several areas of the country. The extended drought focused attention as never before on the environmental concerns of fossil fuel combustion. These events will shape our energy future. In the 21st century, we see a growing demand for electricity, world-wide emphasis on economic competition, and a heightened environmental sensitivity.

Today we have some very promising, innovative reactor design concepts that appear to respond to the needs of the 21st century — they are efficient, competitive, and above all, safe. We must, however, carry out the necessary technology development and validation to support the design and licensing of these concepts in order to turn the promise into reality.

Sound technology is the key to our nuclear future, Madam Chairman, and I would like to call the Committee's attention to two areas which deserve your support — **MHTGR Technology** and **Strategic Technologies for the Advanced LMR**.

MHTGR Technology

Madam Chairman, you will recall that the motivation to explore the possibility of small, passively safe HTGR systems originated in a recommendation from this Committee. Specifically, a November 16, 1983, letter from Marilyn Lloyd and Don Fuqua suggested this direction and called for comment and testimony in planning for the FY-1985 budget. The Modular High-Temperature Gas-Cooled Reactor (MHTGR) concept evolved from this initiative and is the product of your leadership. It is one in which we in the technical community and especially this Committee can be justifiably proud.

Several other countries are also moving to develop this technology. Unfortunately from a competitive perspective, they are developing the concept more aggressively than we are. Japan is currently spending about $60 million/yr on this technology and has just made a high-level government commitment of approximately $700 million to build a 30 MW High-Temperature Test Reactor in Japan. The Federal Republic of Germany is spending approximately $90 million/yr including about $22 million from industry. As you know, they are already marketing the technology to the USSR and China. Even Switzerland is spending about $9.5 million/yr in high-temperature gas-cooled reactor technology. We have a great idea in the MHTGR, but our failure to implement the MHTGR Technology Development Plan prepared by the program over two years ago is hurting our competitive position in the world market.

While the design assumptions made during the MHTGR conceptual design seem reasonable, they must be validated. Without this validation, we cannot license or build an MHTGR. This is the purpose of the MHTGR technology development program for which Oak Ridge National Laboratory (ORNL) has the lead responsibility. The Technology Development Plan focuses on fuel performance, fission product behavior, graphite and metals performance, reactor physics, thermal hydraulics, and shielding. The work outlined in the Plan is essential for validating design methods and demonstrating the licensability and performance of the MHTGR.

The Technology Development Plan requires seven years to complete at a cost of about $12 million per year. In each of the last two years, we have pursued only about one-third of the planned efforts because of budget constraints. **Technology is now the pacing item on the critical path.** The technology development program requires significant irradiation data on fuels and structural material. The time required to prepare an experiment, assemble it, accumulate the requisite irradiation exposure, complete post-irradiation investigation and analyses, and integrate the results into design methods is considerable and cannot be condensed significantly. Because these experimental activities require a substantial investment of time, it is imperative that the technology effort be pursued aggressively now if the MHTGR is to be considered a viable option for either the civilian or the New Production Reactor (NPR) application.

In the President's FY-1990 budget recommendation, funding is included for the MHTGR in both the civilian ($15 million) and the NPR ($115 million) programs. A civilian program budget of $35 million is required to support design, licensing, and technology development schedules consistent with deployment of a first plant by the late 1990s. ORNL believes the civilian program should be fully funded so as to support both commercial and NPR applications. In this regard, we recommend that:

- **The Congress support the civilian MHTGR program at a level of $35 million in FY 1990 to fund design, licensing, and technology development tasks. Included in this work are design and technology tasks which focus on the civilian application but which are also generally supportive of the NPR application. Of this, $12 million should be directed specifically to MHTGR base technology development.**

- **Design and technology tasks focused on the MHTGR-NPR be funded directly through the Office of New Production Reactors.**

Why? Design of the civilian and NPR applications may take divergent paths because of different priorities or constraints, but technology is the common base that supports both applications. Technology development is ORNL's primary responsibility, and how it is organized will influence both cost and effectiveness. For example, international collaboration has been assumed in our technology development plans. As I have stated, the combined total of Japanese and Federal Republic of Germany activities is in the order of $150 million per year. This collaboration leverages our research dollars, provides an opportunity for peer review, and enhances our assurance of quality and safety by providing mutual verification of key data and conclusions. International collaboration cannot be accomplished if the U.S. program is performed under a defense (weapons) mission — it would be politically unacceptable and possibly even illegal for our international partners. If we do not have a viable civilian MHTGR program, our international collaboration is in jeopardy.

In addition, this approach will enhance our technology transfer to U.S. industry and utilities. As you well know, Madam Chairman, from your own experience in dealing with technology transfer legislation, it is simply more difficult to transfer technology developed under atomic energy defense funding.

The deployment of the MHTGR as a New Production Reactor can both complement and build on the extensive knowledge base established in the civilian MHTGR program. However, we urge the Congress to recognize the need to focus the MHTGR technology within the civilian program, because it will be more cost-effective and will remove the potential barriers to civilian application.

Strategic Technologies for the Advanced Liquid Metal Reactor

The long-term importance of the Liquid Metal "Breeder" Reactor in providing technology to extend the uranium resource is inevitable. If the greenhouse effect leads to accelerated deployment of nuclear energy, the need for the breeder may come earlier than the middle of the next century as currently expected.

Recently DOE and its contractors have begun to consider the application of LMR technology for another possibly nearer-term mission — burning the long-life actinides in nuclear waste. This general idea has been evaluated in the past and rejected; but, in the interim, both circumstances and technology have evolved. ORNL supports a reevaluation of this alternative based on a broad systems approach to the entire nuclear fuel and waste cycle — considering reactor designs, fuel forms, reprocessing, transportation, environmental controls, public acceptance, and waste management. It should be noted that such an application would not in any way obviate the need for the current high-level waste repository plan.

In light of the certain long-term and potential near-term need for LMR technology, it is prudent to continue the Advanced LMR design effort and supporting technology development including fuel reprocessing technology. By maintaining a modest, focused program we retain the flexibility and resilience necessary to respond quickly when the need to accelerate is recognized.

The liquid-metal- (sodium) cooled fast breeder reactor (LMFBR) is the system of choice for breeding. Much of the technology development effort for a viable breeder reactor and fuel reprocessing concept using oxide fuel has been completed. This technology has also received major development effort in Western Europe (led by France), in Japan, and in the USSR. Experimental or demonstration reactors have been completed in each major program. This valuable oxide technology should be maintained in readiness for deployment.

The continuing effort beyond the current state of the art should be focused on those aspects of design and technology development which will expand expertise, support investigation of innovative ideas, and enhance the safety and economics of the breeder reactor and fuel-recycle technology.

In light of this overall strategy, we recommend that the Advanced LMR program be focused in two general areas:

- **Innovative ideas which increase design options and uses for future Advanced LMRs and enhance their safety, reliability, and economics. These include, for example, the use of metal fuel, actinide burning, passive safety design and design simplicity.**

- **Strategic technology development which is applicable to all reactor and fuel cycle concepts. These include advanced controls and instrumentation, modular design, seismic isolation, materials and structural design, shielding, and other generic technology development and dissemination areas.**

The first emphasis ensures that the best possible Advanced LMR design will be available when needed. The second emphasis maintains and expands the generic technology base needed for long-term nuclear deployment and to support international agreements. Past experience has shown that much of this base technology development can be applied to existing and near-term projects under consideration by DOE [i.e., MHTGR, Advanced Light Water Reactor (ALWR), New Production Reactor (NPR), SP-100, and Advanced Neutron Source (ANS)].

Strategic Technology programs at ORNL are a small but vital part of this continuing Advanced LMR effort. ORNL Strategic Technologies include:

- Advanced Controls (ACTO) Program incorporating advances in control theory, artificial intelligence (AI), man-machine interface, and information management
- Advanced Instrumentation for Reactor Systems
- Advanced Shielding Materials and Methods
- High-Temperature Materials and Structural Design

ORNL has played a strong national role in each of these technologies over many years, and has established an international preeminence in these areas. No funds are provided in Strategic Technologies in the President's FY-1990 budget recommendation for Advanced Controls (ACTO), Advanced Instrumentation, or Materials and Structural Design. The Shielding experimental program is funded at $1 million.

We recommend that the Congress support Strategic Technologies for the Advanced LMRs and authorize an additional $8.0 million to continue work on:

Advanced Controls (ACTO)	$5.5M
Advanced Instrumentation	$0.8M
Shielding	$0.1M
Materials and Structural Design	$1.6M

This budget level would maintain critical support for key experienced research staff and allow us to make significant progress in these technologies. The Committee's support is urgently needed to avoid further erosion in our technology base. At a time when electric power demand is increasing twice as fast as projected and significant brownouts are beginning to occur, we must look beyond today to the future. The 21st Century must be a nuclear one — built on a new generation of nuclear technology. To remain competitive, the U.S. must make a commitment to establish this technology.

The following discussion highlights the significance of these Strategic Technologies and the scope of work proposed for FY 1990:

Advanced Control (ACTO). Modern digital control technology is beginning to be implemented by existing nuclear plants on a limited basis to replace the failure-prone analog control systems of the past. All, let me repeat, all advanced reactor concepts plan to use aspects of this advanced technology. The purpose of the ACTO program is to provide the supporting technology base to allow designers to implement this technology effectively.

This includes validated design methods, tools, and computer codes, as well as selected demonstrations to illustrate the technology. During this past year, many significant advances have been made:

- A demonstration conceptual prototype control system design for the steam side of an Advanced LMR has been completed.
- A demonstration showing how an advanced control system could be designed to provide supervisory control to an Advanced LMR was completed.
- A prototype control system designer's workstation using advanced computing technology, artificial intelligence, and advanced graphical interfaces was completed.
- Several advanced computer simulation tools were acquired and integrated into an ACTO Advanced Computer Laboratory.

This program is focused on the Advanced LMR concept, but it also supports near-term LWR applications as well as other advanced concepts. Consider the following applications of the technology which provide some indication of its value:

- The Advanced LMR design team led by GE proposed DOE technology development in advanced controls (including the ORNL ACTO program).
- The Electric Power Research Institute (EPRI) asked ORNL's ACTO program personnel to help prepare the Advanced LWR Requirements Document section on Man-Machine Interface.
- The utility industry B&W Owners Group has asked ORNL ACTO program personnel to provide technical support for a major upgrade in the feedwater control system for their reactors.

The ACTO long-range program plan calls for an increase in operating budget from $3 million in FY 1989 to $4 million in FY 1990 and an FY-1990 capital equipment budget of $1.5 million. The success of these applications as well as benefits to the MHTGR, NPR, ANS, and other applications are vital to our nuclear future.

Advanced Instrumentation. Advanced instruments under development at ORNL include an improved neutron flux monitoring system featuring high-temperature operation and advanced electronics. A prototype system is now being prepared for test. An automated noise data acquisition system for noise diagnostics has also been developed and is undergoing prototype testing in the

Fast Flux Test Facility (FFTF). A program funding level of $800 thousand is requested for FY 1990 to allow pre-irradiation qualification of the high-temperature high-sensitivity fission counter prototype during FY 1990 and its subsequent installation in the EBR-II for irradiation testing. This funding level also would permit further needed development on the noise signature analysis system that will provide expert advice to assist the reactor operator in making operating and maintenance planning decisions.

Shielding. The Advanced LMR design being developed by GE has identified several shielding design needs which require the analytical and experimental support of ORNL. The design requirement of a physically small reactor vessel and the innovative design and placement of in-vessel components give rise to special shielding issues whose resolution require advanced analysis techniques and experimental validation. GE has specifically requested DOE technology development support from ORNL's Shielding Program in their technology requirements plan.

An experimental shielding program is in progress at the ORNL Tower Shielding Facility (awaiting approval for restart of the reactor). It addresses several leading Advanced LMR shielding issues including: advanced materials and designs for the radial and axial shields, the feasibility and shielding-related impact of spent fuel stored within the reactor vessel, and plant exposure levels resulting from activation of secondary sodium and radiation "leakage" from the vessel enclosure system. The program is cooperatively funded by PNC (Japan), who needs the same data to support their current LMR designs. This collaboration provides a cost-effective way of obtaining the required shielding data.

The budget requirement in FY 1990 includes $1.5 million to continue the experiment program, $700 thousand of which will be provided by PNC (Japan). An additional $350 thousand is needed to provide sufficient analysis support to allow GE to advance their Advanced LMR design with respect to the placement and shielding of in-vessel components, the location and response of the flux monitoring system, and the feasibility and location of their failed-fuel detection system.

High-Temperature Materials and Structural Design. For over two decades, ORNL has played a lead role in DOE's high-temperature materials and structural design technology program. The bulk of this effort has been completed, and it has resulted in improved materials and design methods for high-temperature application. The remaining program required to support design methods, code qualification, and licensing for the Advanced LMR was recently developed by ORNL, GE, RI, and DOE, and is presented in a DOE national program plan. A significant part of this overall effort is concerned with finalizing work on modified 9Cr-1Mo steel, which is an advanced alloy developed at ORNL over the last 12 years specifically for advanced high-temperature reactors. In addition to the Advanced LMR, this technology supports other high-temperature applications such as the MHTGR and NPR-HTGR.

The plan calls for the addition of modified 9Cr-1Mo steel to the design methodology and data base so that advantage can be taken of its superior mechanical and physical properties in advanced reactor plants. The effort includes generation of design data, identification of appropriate design analysis methods and failure criteria, and development of high-temperature fracture assessment procedures needed for reactor safety and reliability assessments. The plan also addresses a number of remaining critical materials and structural design issues involving more traditional materials and design methods as well as data needs associated with longer design lives and passive safety features of advanced reactors. The planned FY-1990 budget for this program is $1.6 million.

Mrs. Lloyd. Thank you very much, Dr. Jones.

Dr. Chang, please proceed.

STATEMENT OF DR. YOON CHANG, GENERAL MANAGER, IFR PROGRAM, ARGONNE NATIONAL LABORATORY

Dr. Chang. Madam Chairman, Members of the Subcommittee, I am Yoon Chang, General Manager of the IFR Program at Argonne National Laboratory. I appreciate the opportunity to speak to the Subcommittee on behalf of Dr. Charles Till, who has testified each year on the IFR technical advances and demonstrations. I regret that Dr. Till could not make it today and I will try to convey the main points that he wished to make.

The past year was no exception and we have made substantial technical progress in all aspects of the IFR program. The irradiation tests on the new metallic fuel in EBR–II have now surpassed 18½ percent burnup. This is a major technical accomplishment, and the high burnout capability of metallic fuel is now fully demonstrated.

The demonstration of the key IFR processing step has now moved up from laboratory scale to engineering scale. Ten-kilogram amounts of uranium have been electrotransported routinely. All major process equipment are in the final design phase or actually are in the prototype fabrication stage.

Solid technical accomplishments have been accumulating year after year. But as we make technical progress, the ultimate potential offered by the IFR concept becomes clearer and clearer. The IFR concept can meet all three fundamental requirements needed in a next generation reactor.

First, the next generation reactor should be capable of meeting large energy demands. Rising concern about the greenhouse effect reinforces the need to reexamine the requirements of a next-generation reactor concept so that it can contribute significantly toward the substitution for fossil-based energy generation. The IFR can extend uranium resources by a hundredfold, making nuclear essentially the same as a renewable energy source.

Second, the next generation reactor should have inherent safety characteristics and should be simple to operate. The inherent safety potential of the IFR concept was demonstrated through the landmark tests conducted at EBR–II in April 1986. Dr. Till described the details of this exciting safety demonstration before the Subcommittee two years ago.

Third, nuclear waste is now the factor that probably most influences public acceptance of nuclear power so the next generation reactor should have specific technical solutions to deal with the high-level waste disposal. High-level nuclear waste is composed of fission products and actinides. The fission products decay to a sufficiently low level in a time span of the order of a few hundred years. Actinides, on the other hand, typically have very long half-lifes and their radiological risk factors remain high for hundreds of thousands of years. The IFR concept has a promising potential for separating actinides from the waste stream and recycling them back into the reactor for in-situ burning, hence reducing the lifetime of nuclear waste from millions of years to a few hundred years.

But it should also be realized that even if the actinides are removed and the everlasting nature of the waste is eliminated, the need will remain for a geologic repository.

We are at a critical juncture in IFR technology development. The breeding principle has long been established. The inherent safety potential has been demonstrated through actual plant tests. The key next step is to demonstrate the IFR fuel cycle, including the waste management processes. Rapid progress is being made to allow a prototype demonstration of the entire IFR fuel cycle in conjunction with the EBR-II to begin in October of 1990. Once again, however, we are deeply concerned about the lack of funding support to complete this technology development.

The Department of Energy budget for the IFR program has been reduced from $29.1 million in FY 89 to $6.1 million in FY 1990. Such a precipitous drop in funding cannot be accommodated in any way that will allow reasonable progress in IFR development. To bring the IFR program back to this year's levels requires a $20 million funding increment.

The IFR technology is based on major innovations and radically new processes. The progress to date has been in terms of real and tangible scientific accomplishments. It is easy to cite dramatic improvements or high potential in paper studies. Proving improvements and demonstrating potential requires a real R&D and a test and experimental infrastructure to support it. The test facilities at ANL-West play a crucial role.

These facilities, coupled with the first-rate technological expertise at Argonne, have given us the IFR technology that promises a real next-generation advanced reactor technology. We hope that the $20 million incremental funding request for the IFR will be viewed in this light.

Madam Chairman, we at Argonne thank you and the Subcommittee for this opportunity to speak today and for the continued support given to the IFR over the past years. I would like to submit my written testimony for the record.

Mr. STALLINGS [presiding]. It will be made part of the record.

Thank you, Dr. Chang.

[The prepared statement of Dr. Chang follows:]

TESTIMONY

PRESENTED TO THE SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT
OF THE
HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

March 1, 1989

YOON I. CHANG

General Manager
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Statement of

Yoon I. Chang

General Manager, IFR Program
Argonne National Laboratory

To the

Subcommittee on Energy Research and Development
of the
House Committee on Science, Space, and Technology
U.S. House of Representatives

March 1, 1989

Madam Chairman, members of the Subcommittee, I am Yoon Chang, General Manager of the IFR Program at Argonne National Laboratory. I appreciate the opportunity to speak to the Subcommittee on behalf of Dr. Charles Till, who first appeared before this Subcommittee five years ago to urge support for the Integral Fast Reactor and has testified each year on the IFR technical advances and demonstrations. I regret that Dr. Till could not make it today, and I will try to convey the main points that he wished to make.

The past year was no exception, and I am very pleased to report that we have made substantial technical progress in all aspects of the IFR technology development and demonstration. The lead irradiation tests on the new U-Pu-Zr metallic fuel in EBR-II have now surpassed 18.5% burnup, far exceeding their design goal burnup of 10%. This is a major technical accomplishment, and the high burnup capability of the new metallic fuel is now fully demonstrated. Important results were also obtained from in-reactor tests of fuel pins tested beyond cladding breach, showing the benign behavior of breached pins. The initial breach of the fuel pin did not degrade with further irradiation even after 223 days of operation beyond breach. This demonstrated another facet of the superior performance of the metallic fuel.

The demonstration of the key IFR processing step, electrorefining, has moved up from laboratory scale to engineering scale. Ten-kilogram amounts of uranium have been electrotransported routinely. The next step is the plant-scale demonstration in the refurbished EBR-II Fuel Cycle Facility, now called HFEF/S, with actual irradiated fuel from EBR-II. Rapid progress has been made during the past year in making the necessary preparation for facility modifications. All major process equipment systems are in the final phase of design or are actually in the prototype fabrication stage. We expect to complete the facility modifications and the equipment installation and qualification by the end of FY 1990.

Solid technical accomplishments have been accumulating year after year. But as we make technical progress, the ultimate potential offered by the IFR concept as a next generation advanced reactor becomes clearer and clearer. The IFR concept can meet all three fundamental requirements needed in a next generation reactor.

First, the next generation reactor should be capable of meeting large energy demands, demands that are a substantial fraction of the total energy needs of the future. Rising concern about the greenhouse effect reinforces the need to reexamine the requirements of a next-generation reactor concept so that it can contribute significantly toward substitution for fossil-based energy generation. Even with only the limited nuclear capacity on-line today, worldwide reasonably assured uranium resources would last for only about 50 years. If nuclear is to make a significant contribution, breeding is a fundamental requirement. Breeding is not needed today, and probably not in a decade or two either. However, it is certain that it will be needed, if nuclear is to contribute significantly toward the future energy demands. The IFR can extend uranium resources by a hundredfold, making nuclear essentially the same as a renewable energy source.

Second, the next generation reactor should have inherent passive safety characteristics and should also be simple to operate. The inherent passive safety potential of the IFR concept was demonstrated through the two landmark tests conducted in EBR-II in April 1986: loss-of-flow without scram test and loss-of-heat-sink without scram test, both from the full power operating condition. Dr. Till described the details of this exciting safety demonstration before this Subcommittee two years ago. Even under these very severe accident conditions, the reactor shut itself down without intervention of operators or reliance on engineered safety systems. The IFR inherent safety characteristics are due to the unique combination of nuclear properties associated with metallic fuel and high boiling temperature of liquid metal sodium. Sodium has another remarkable characteristic. It is noncorrosive to reactor structural materials. The buildup of corrosion products in the reactor systems and components, which plagued the water cooled reactors, is not an issue for the IFR. Access for maintenance is easy and radiation exposures to plant personnel are very low. Noncorrosive coolant also implies reliable sodium components performance and improved plant availability. The original EBR-II steam generators have operated without leaks over 25 years of continuous service. EBR-II achieved 81.3% capacity factor in 1987 and 79.4% in 1988, even with frequent refueling and other outages to accommodate the various irradiation tests. The sodium pool also acts as a buffer between the reactor and the balance-of-plant, or BOP, so malfunctions in the BOP systems do not challenge the safety of the reactor system. The plant control system can be simplified by taking advantage of these kinds of reactor system responses. An initial series of tests was successfully conducted in EBR-II during the past year to demonstrate these newly-realized excellent operability characteristics.

Third, nuclear waste is now the factor that probably most influences public acceptance of nuclear power so the next generation reactor should have specific technical solutions to deal with the high level waste disposal. High level nuclear waste is composed of two major constituents: fission products that are produced in the fission process and transuranic elements, or actinides, that are produced as a result of neutron capture. From a radiological risk viewpoint, actinides dominate in the long term. In a time span of the order of 200 years, the fission products decay to a sufficiently low level that their radiological risk factor drops below the cancer risk level of the original uranium ore. Actinides, on the other hand, typically have very long half-lifes and their radiological risk factor remains orders of magnitude higher than that due to fission products for tens or hundreds of thousands of years. Therefore, there is a strong incentive to separate actinides and recycle them back into the reactor for in-situ burning.

IFR pyroprocessing has two distinct advantages for separating actinides from the waste stream. First of all, most of the actinides accompany the uranium/plutonium product stream in the IFR process, and the remaining actinides can then be separated from the waste streams more easily than in the PUREX process. The hardened IFR neutron spectrum is better for actinide burning than that of any other reactor type. Thus the potential of the IFR concept to make actinide recycling practical is very promising.

But it should also be realized that even if the actinides are removed and the radiological lifetime of the high-level waste is reduced to a few hundred years, the need will remain for a geologic repository. The everlasting nature of the waste is eliminated, but for decades the activity will still be high and a geologic repository would be still required to store such high-level wastes, regardless of the actinide contents. The benefit of recycling actinides is in the fact that the effective lifetime of the nuclear waste is reduced from millions of years to a few hundred years. This should have enormous impact on assuring the integrity of containment of high-level waste for its lifetime and should also impact ultimately on the public acceptance of nuclear power.

We are at a critical juncture in IFR technology development. The breeding principle has long been established. The inherent safety potential has been demonstrated through actual plant tests at EBR-II as well as experiments at TREAT. The key next step is to demonstrate the IFR fuel cycle, including the waste treatment processes. Rapid progress is being made to allow a prototype demonstration of the entire IFR fuel cycle in conjunction with EBR-II to begin in October 1990. Once again, however, we are deeply concerned about the lack of funding support to complete this technology development.

The Department of Energy budget for the IFR Program has been reduced from $29.1 million in FY 1989 to $6.1 million in FY 1990. Such a precipitous drop in funding cannot be accommodated in any way that will allow reasonable progress in IFR development. The Department's budget submission indicates that potential collaboration with Japan was expected to cover part of the funding shortfall. Although a collaborative program with Japan is under negotiation, the expected Japanese contribution in FY 1990 is a few million dollars at most. To bring the IFR program back to this year's levels requires a $20 million funding increment.

The IFR technology is based on major innovations and radically new processes. The progress to date has been substantial in terms of real and tangible scientific accomplishments. It is easy to cite dramatic improvements or high potential in paper studies. Proving improvements and demonstrating potential through laboratory experiments and plant-scale demonstrations requires a real R&D and a prooftesting and experimental infrastructure to support it. The test facilities at ANL-West play a crucial role: EBR-II for irradiation tests and plant testing, TREAT for accident-simulating transient fuel tests, ZPPR for physics tests, HFEF/N for destructive and nondestructive fuel examinations, and HFEF/S for fuel cycle demonstration. These facilities, coupled with the first-rate technological expertise in all reactor-related disciplines that is present at Argonne have given us the IFR technology that promises a real next-generation advanced reactor technology. We hope that the $20 million incremental funding request for the IFR will be viewed in this light.

Madam Chairman, we at Argonne thank you and the Subcommittee for this opportunity to speak today and for the continuous support given to the IFR over the past years.

Mr. Stallings. Dr. Korenko.

STATEMENT OF DR. MICHAEL K. KORENKO, MANAGER, ADVANCED REACTOR DEVELOPMENT, WESTINGHOUSE HANFORD CO., HANFORD ENGINEERING DEVELOPMENT LABORATORY

Dr. Korenko. Thank you. I am grateful for your invitation to present our views on the direction of nuclear power for this country. Since I was asked to limit my comments to five minutes, I'd like to submit my entire testimony for the record and just highlight a few key points with the use of a few vu-graphs.

Mr. Stallings. Thank you. Your testimony will be made part of the record.

[Slide.]

Dr. Korenko. For those of you who have never had the opportunity to visit Hanford, we are located in the State of Washington, in the heart of the desert next to the Columbia River. I would really like to invite the full Committee or Subcommittee to visit us. Particularly if you want to assess the facilities, it is, I think important to see the facilities that are being assessed.

[Slide.]

On this site are two of the most modern nuclear facilities in the DOE complex, FFTF or the Fast Flux Test Facility, and FMEF.

FFTF has been thoroughly reviewed by NRC. Its operating practices and procedures meet or exceed contemporary nuclear industry standards. It has only been in operation for six years. Therefore it has the greatest probability for sustained operation beyond the year 2000.

I would like to emphasize that point. Of all the reactors in the Department of Energy today, this is the youngest. It's probably the one that has the best chance of operating for another 20 years to the turn of the century, and that is something that I think is significant and in a sense this should be considered as a national asset.

The FMEF shown in the foreground is a brand new concrete structure, five stories tall, which is riddled with hot cells specifically built for processing. It meets or exceeds the current seismic, tornado, and security standards.

This complex is ideally suited to produce Pu-238 for space power and to serve as an irradiation test center for the development of liquid metal, fusion, light water, gas, waste burn and space power concepts.

[Slide.]

I would like to shift gears to our country's space missions. As this graph illustrates, as our space missions evolve to higher and higher powers for longer and longer times, we must rely more and more on nuclear power. Currently the focus is centered on Pu-238-fueled radioisotope power generators, and in the future will evolve to SP-100. If the country wants to continue to exert a leadership in space, it must embrace nuclear power as it has in the past. There is no other choice.

[Slide.]

You may have seen these pictures of Jupiter and its moons. The point is, this is a nuclear photograph.

[Slide.]

Similarly, Saturn and its moons, this is a nuclear photograph. Our Mars lander had a lunar pack.

[Slide.]

On the moon, the device resting in the surface is a nuclear power pack. The public that we have talked to in our speaking engagements are very comfortable with nuclear power in space and very comfortable with the continuation of this country's efforts using nuclear in space.

[Slide.]

The first question that is asked with respect to Pu-238 is how much do we need? This slide shows the amount of material in kilograms needed to support our country's missions. The FFTF and FMEF complex can meet these needs.

[Slide.]

I'd like to show you what one of these power devices looks like. This is the next Jupiter probe. If you remove its cover, it would look as shown in the following slide.

[Slide.]

The pink blocks are actually black. The artist took a little liberty there. They are made of graphite, about the size of a softball, and they generate about 120 watts of power, about like a bright light bulb. You can add as many of these power packs to your missions as you desire.

[Slide.]

This pink block is shown on the next slide, and you can see it actually is black. The small fuel pellets shown on the slide actually contain the Pu-238 that generates the heat.

[Slide.]

This is the bank of hot cells in our FMEF facility that we will use to manufacture these power packs.

[Slide.]

This is a cross-section of our reactor core at FFTF. It is about four feet in diameter and about 30 feet long, and those little hexagons are about that big around (indicating.) Try to record that. The Pu-238 production occurs in this outer ring in space previously not used, in our reflector region. This leaves the main core to continue and expand our current mission of an irradiation test center.

The blue assemblies in the middle represent our new international fusion device, prototypic space power assemblies, liquid metal reactor assembly tests, and a proposed waste burn test. The white area is where we test oxide, metal and nitride fuels to support long-life cores, IFR, and space power.

By producing and selling Pu-238, approximately one-half of our future facility costs can be removed from the current customers by the year 1994. In other words, we sell the Pu-238 that we generate and that reduces our facility costs. I think this is one answer to the dilemma of how to expand our research efforts and still maintain our modern facilities.

In conclusion, FFTF is a six-year-old reactor and a very reliable long-term source of neutrons. It is a national asset that must be available at the turn of the century.

We appreciate the continued support of this Committee for our facilities and our development efforts. Thank you.

Mr. STALLINGS. Thank you, Dr. Korenko.

[The prepared statement of Dr. Korenko follows.]

TESTIMONY
BEFORE THE
U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

DR. M. K. KORENKO
MANAGER
ADVANCED REACTOR DEVELOPMENT DIVISION
WESTINGHOUSE HANFORD COMPANY

MARCH 1, 1989

BIOGRAPHICAL INFORMATION

MICHAEL K. KORENKO

As manager, Advanced Reactor Development Division, Dr. Korenko's responsibilities include: managing $110M worth of programs, approximately 550 people, and over a billion dollars worth of facilities. This includes directing operation of the Fast Flux Test Facility and associated fuel fabrication operations, the Fuels and Materials Examination Facility, and the SP-100 Space Power Test Site. His programs cover a wide range of activities including liquid metal reactors, fusion, medical isotope production, waste disposal, and robotics.

Dr. Korenko received a B.S. in Metallurgy from Case Institute of Technology; a M.S. in Materials Engineering from Case-Western Reserve University; and a Sc.D. in Materials from MIT. Dr. Korenko joined Westinghouse Hanford Company in 1974 after performing a year in post-doctoral research at Oxford University. As a scientist at WHC, he received 14 patents for advanced materials, and received the company's 1977 "Invention of Year Award."

He was selected as one of the 14 White House Fellows from among several thousand applicants in 1980-1981, and served as a staff assistant to Secretary of Defense Weinberger under the fellowship. He returned to Westinghouse and was named to a series of high-level corporate positions in Pittsburgh. Prior to returning to WHC, he was manager of business development for the Westinghouse Advanced Power Systems Division where he spearheaded the corporate thrust to transfer technology from federal laboratories to the commercial sector. He was selected as the 1983 Quality Manager of the Year. Prior to his present position, Dr. Korenko was manager of Applied Systems Development and was responsible for program diversification.

FFTF/FMEF - THE MULTIMISSION FACILITY

MADAME CHAIRMAN AND MEMBERS OF THE SUBCOMMITTEE:

I AM GRATEFUL FOR YOUR INVITATION TO PRESENT OUR VIEWS ON THE DIRECTION OF NUCLEAR POWER FOR THIS COUNTRY. I WILL LIMIT MY COMMENTS TO YOUR FIVE-MINUTE CRITERION, BUT WOULD LIKE TO SUBMIT MY ENTIRE TESTIMONY FOR THE RECORD. YOU ASKED SPECIFICALLY THAT I COVER OUR FACILITY COSTS AND I HAVE DONE THAT IN THE APPENDIX OF MY TESTIMONY.

TWO OF OUR COUNTRY'S BASIC NEEDS ARE: PU-238 FOR SPACE APPLICATIONS, AND AN IRRADIATION TEST CENTER TO DEVELOP HTGR, LMR, FUSION, WASTE BURN AND SPACE POWER CONCEPTS. FFTF CAN FULFILL BOTH NEEDS SIMULTANEOUSLY FOR THE NEXT 20 YEARS. APPROXIMATELY ONE HALF OF OUR FUTURE FACILITY COSTS WILL BE PAID FOR BY PU-238 SALES, THE PU-238 CAN BE PRODUCED AT A COMPETITIVE COST, AND SUCH PRODUCTION WOULD RESULT IN A 50 PERCENT REDUCTION OF COSTS TO OUR IRRADIATION TEST CUSTOMERS BY THE END OF 1993. PLACING THE PU-238 MISSION AT HANFORD IS AN EXCELLENT WAY TO REDUCE THE EFFECTIVE OPERATING COSTS OF OUR IRRADIATION TEST FACILITIES.

THE FAST FLUX TEST FACILITY (FFTF) IS THE MOST MODERN AND RELIABLE SOURCE OF NEUTRONS IN THE DEPARTMENT OF ENERGY. OPERATING PRACTICES AND PROCEDURES MEET OR EXCEED CONTEMPORARY NUCLEAR INDUSTRY STANDARDS. IT IS THE MOST MODERN NRC-REVIEWED REACTOR AMONG THE DEPARTMENT OF ENERGY FACILITIES, AND, THEREFORE, HAS THE GREATEST PROBABILITY FOR SUSTAINED OPERATIONS BEYOND THE YEAR 2000.

FFTF IS LOCATED NEXT TO THE FUELS AND MATERIALS EXAMINATION FACILITY (FMEF) WHICH IS ONE OF THE NEWEST NUCLEAR FACILITIES IN THE COUNTRY. HAVING THE MOST MODERN REACTOR NEXT TO A MODERN

PRODUCTION FACILITY IS WHY THIS COMPLEX IS BEST SUITED TO PERFORM THE SPACE ISOTOPE MISSION, ALSO KNOWN AS PLUTONIUM-238 PRODUCTION. THE FMEF WILL BE USED TO PROCESS THE PU-238 PRODUCED AND ASSEMBLE RADIOISOTOPE THERMOELECTRIC GENERATORS. THIS IS CONSISTENT WITH THE DOE THRUST TO MODERNIZE ITS FACILITY INFRASTRUCTURE.

FFTF CAN FOCUS ON PRODUCING PLUTONIUM-238, GENERATE OTHER ISOTOPES FOR MEDICAL APPLICATIONS THROUGH A TEAMING ARRANGEMENT WITH OAK RIDGE NATIONAL LABORATORY, AND STILL RETAIN ITS CURRENT MISSION TO BE AN IRRADIATION TEST CENTER FOR THE COUNTRY.

FFTF IS CONTINUING TO FULFILL ITS DESIGN OBJECTIVE OF BEING A RELIABLE SOURCE OF NEUTRONS FOR IRRADIATION TESTING. IT HAS SPECIAL TESTING FEATURES AND THE BEST TEST INSTRUMENTATION OF ANY REACTOR IN THE WORLD. ITS NEUTRONS ARE CURRENTLY BEING USED TO TEST FUSION, SPACE POWER, AND LIQUID METAL REACTOR CONCEPTS FOR DOMESTIC AND INTERNATIONAL PROGRAMS.

WE ARE PROUD OF OUR ACCOMPLISHMENTS DURING THE YEAR SINCE OUR LAST TESTIMONY. SINCE WE ARE A MULTIMISSION FACILITY, OUR CONTRIBUTIONS CAN BEST BE DESCRIBED BY PROGRAMS:

LIQUID METAL REACTOR

THE MOST IMPORTANT ASPECT OF COMMERCIALIZING A NEW REACTOR TECHNOLOGY IS TO DEMONSTRATE RELIABLE, SUSTAINED, COST-EFFECTIVE OPERATION. LAST YEAR FFTF BROKE TWO SIGNIFICANT OPERATING RECORDS--IT EXTENDED ITS PREVIOUS LMR WORLD RECORD OF CONTINUOUS OPERATION FROM 105 TO 126 DAYS, AND ITS 78% CAPACITY FACTOR BETTERED THE 76% ACHIEVED IN 1987 AND REPRESENTS EXCELLENT, SUSTAINED PERFORMANCE.

THE PERFORMANCE CAPABILITY OF A LONG-LIFE REACTOR CORE FUELED WITH MIXED URANIUM-PLUTONIUM OXIDE AND USING LOW-SWELLING ALLOYS FOR CLADDING AND STRUCTURAL COMPONENTS WAS DEMONSTRATED IN SEVERAL FFTF ACCOMPLISHMENTS.

- THE HIGHEST EXPOSURE OF A FULL-SIZED, FULL-LENGTH MIXED OXIDE FUEL ASSEMBLY WORLD WIDE WAS ACHIEVED. THE ASSEMBLY SURVIVED 1500 DAYS OF OPERATION AT FULL POWER FOR A BURNUP OF 190,000 MWd/MTM, OR 20 ATOM PERCENT.

- LEAD TESTS IN THE HIGH PERFORMANCE CORE DEMONSTRATION EXPERIMENT (CDE), WHICH USES NON-SWELLING HT9 CLADDING AND DUCTS HAVE EXCEEDED THE GOAL EXPOSURE OF 900 DAYS AT FULL POWER BY TEN PERCENT AND ARE EXPECTED TO CONTINUE TO BEYOND 1200 FULL POWER DAYS.

- FUEL PIN TESTS DEMONSTRATED AN INHERENT SHUTDOWN SAFETY CAPABILITY FOR THE CDE DESIGN IN THE EVENT OF AN OVERPOWER TRANSIENT.

- MEASUREMENTS CONTINUE TO CONFIRM THE NON-SWELLING CHARACTERISTIC OF HT9 STEEL TO EXTREMELY HIGH NEUTRON EXPOSURES.

THESE ACCOMPLISHMENTS BRING US VERY CLOSE TO THE GOAL OF REDUCING FUEL CYCLE COSTS OF THE LIQUID METAL REACTOR BY A FACTOR OF THREE, COMPARED WITH THE INITIAL DESIGN.

WE ARE ALSO IRRADIATING SEVERAL METAL FUEL ASSEMBLIES WHICH SERVE TWO PURPOSES: FUEL SUPPLY, AND DEMONSTRATION OF FUEL ASSEMBLIES THAT ARE NEAR PROTOTYPIC TO CORE SIZE OF THE U.S. ADVANCED LIQUID METAL REACTOR (PRISM).

A FFTF CONTROL ROD ASSEMBLY DEMONSTRATED 1100 DAYS OF FULL POWER ACCUMULATING AN UNPRECEDENTED NUMBER OF NEUTRON CAPTURES. THIS IS THE HIGHEST KNOWN EXPOSURE IN THE WORLD.

EXCELLENT COLLABORATION WITH THE JAPANESE HAS RESULTED IN THE START OF IRRADIATION IN FFTF OF TWO FULL-SIZE FUEL AND ONE BLANKET

ASSEMBLIES WHICH ARE INTENDED TO VERIFY THE PERFORMANCE OF CORE COMPONENTS WHICH WILL BE USED IN THE JAPANESE MONJU REACTOR. MONJU IS SCHEDULED TO START OPERATIONS IN 1992. THESE SUCCESSES ARE IMPORTANT TO THE EXTENSION OF THIS INTERNATIONAL COLLABORATION AND THE POSSIBLE INFUSION OF SEVERAL MILLIONS (UP TO $30M) OF ADDITIONAL DOLLARS FOR LARGER NUMBERS OF JAPANESE TESTS IN FFTF.

WE ARE PROPOSING THREE FUTURE THRUSTS WHICH PROVIDE EXAMPLES OF HOW TO DEVELOP TECHNOLOGY UNDER SEVERE FUNDING CONSTRAINTS. FIRST, AS WE CONTINUE TO UPGRADE THE FFTF, WE ARE PROPOSING THAT ANY COMPONENT UPGRADES BE AS CLOSE TO THE PRISM REACTOR DESIGN AS POSSIBLE. THUS, THE DOLLARS INVESTED IN FACILITY UPGRADES WILL SERVE THE DUAL PURPOSE OF KEEPING FFTF MODERN, AND PROOF TESTING COMPONENTS FOR ADVANCED REACTORS. SECONDLY, OUR PROPOSED POWER ADDITION PROJECT AND ITS ADJACENT STEAM GENERATOR TEST STATION WOULD NOT ONLY REDUCE DOE'S OPERATIONAL COSTS, BUT IT COULD ALSO TEST CRITICAL ADVANCED REACTOR COMPONENTS AND STEAM SYSTEMS OF INTERNATIONAL AND U.S. DESIGN. THIRDLY, THE FINAL PHASE OF THE SPACE ISOTOPE PROGRAM WILL PROCESS IRRADIATED FFTF FUEL TO RECOVER NEPTUNIUM FOR RE-IRRADIATION TO PRODUCE PU-238. A SECONDARY BENEFIT IS THAT THIS PROCESSING WILL DEMONSTRATE A CRITICAL LONG-TERM TECHNOLOGY REQUIRED FOR ECONOMICAL LIQUID METAL REACTORS, I.E., CLOSING THE FUEL CYCLE.

SPACE POWER

CLEARLY THIS COUNTRY MUST CONTINUE TO EXPAND ITS USE OF NUCLEAR POWER IF WE ARE TO MAINTAIN A STRONG PRESENCE IN SPACE. HANFORD IS DEEPLY INVOLVED IN THREE OF THESE EFFORTS: RADIOISOTOPE THERMOELECTRIC GENERATORS (RTG'S), SP-100, AND MULTIMEGAWATT REACTOR DEVELOPMENT.

(RTG) THE FMEF HAS BEEN SELECTED BY DOE TO ASSEMBLE PLUTONIUM-238 HEAT SOURCES FOR SPACE AND TERRESTRIAL APPLICATIONS. A PORTION OF FMEF WILL BE MODIFIED AND EQUIPPED TO BECOME THE RADIOISOTOPE

POWER SYSTEMS FACILITY (RPSF) FOR THIS PURPOSE. WE ARE PROCEEDING ON COST AND ON SCHEDULE TO COMPLETE THE RPSF FOR THE ASSEMBLY and test OF GENERAL PURPOSE HEAT SOURCES WHICH WE WILL ASSEMBLE INTO RTG'S. OUR SCHEDULE MEETS THE ASSEMBLY REQUIREMENTS FOR NASA'S COMET RENDEZVOUS ASTEROID FLYBY (CRAF) MISSION.

FURTHER, IN THE FFTF/FMEF COMPLEX, WE CAN PRODUCE 19 KGS OF PU-238 IN EARLY 1994, MAKING IT THE NEAR-TERM, AS WELL AS THE LONG-TERM, SUPPLIER OF THIS CRITICAL ISOTOPE TO FUEL THE CASSINI SPACE CRAFT AND OTHER IMPORTANT FUTURE MISSIONS.

(SP-100) FFTF HAS JUST COMPLETED TWO VERY SUCCESSFUL IRRADIATIONS OF SP-100 MATERIALS AND FUELS:

- HUNDREDS OF MATERIAL PROPERTIES SPECIMENS WERE IRRADIATED IN THE MATERIALS OPEN TEST ASSEMBLY (MOTA) CANISTERS AT WHITE HOT TEMPERATURES. THIS EXTREME TESTING, WHICH IS IN EXCESS OF DESIGN OPERATING TEMPERATURES, IS CONSISTENT WITH THE SP-100'S EMPHASIS ON SAFETY UNDER ALL CONDITIONS. THIS WAS THE FIRST INSTRUMENTED AND TEMPERATURE-CONTROLLED MATERIALS IRRADIATION TEST TO ALLOW PROTOTYPIC DESIGN CORRELATIONS FOR SP-100 MATERIALS PERFORMANCE. Preliminary indication from detailed monitoring of test elements shows outstanding high temperature performance of these materials

- THE FUELS TEST FSP-1, WILL PROVIDE THE WORLD'S FIRST FAST REACTOR DATA ON AN ADVANCED MATERIAL, RHENIUM, WHICH WILL ENSURE ACHIEVING THE DESIGN LIFETIME OF THE SP-100 FUEL PINS. THIS SINGLE TEST, WHICH CONTAINS 38 FUEL PINS, TRIPLES THE AVAILABLE FAST REACTOR FUEL PIN DATA BASE OVER THAT PREVIOUSLY AVAILABLE TO THE SP-100 DESIGNERS.

(MMW) WITH RESPECT TO THE MULTIMEGAWATT program and its initial phase one studies of ~~concept~~ CONCEPT, WE HAVE JUST REMOVED A KEY THERMIONICS MATERIALS TEST FROM FFTF, AND THE COMPONENTS TESTED ARE UNDERGOING DETAILED EXAMINATION. THE KEY ISSUE OF ELECTRICAL INSULATOR LIFETIME, UNDER FAST NEUTRON

IRRADIATION, HAS A SOLUTION. THE ALUMINA INSULATORS SURVIVED TWICE THE EXPOSURE EXPECTED IN SPACE APPLICATIONS AND RETAINED EXCELLENT ELECTRICAL AND MECHANICAL PROPERTIES. WE ARE NOW TESTING AND EXAMINING ADDITIONAL ADVANCED MATERIALS TO SUPPORT EXTENSION OF THIS TECHNOLOGY TO HIGHER POWERS. WE ARE ALSO DESIGNING A LARGER, PROTOTYPIC, STRING TEST AS WE EVOLVE TO FULL COMPONENT TESTING IN FFTF.

FUSION

WE RECENTLY COMPLETED FABRICATION OF THE FUSION MATERIALS OPEN TEST ASSEMBLY. THIS IS AN EIGHT-YEAR TEST TO BE INSERTED IN JUNE OF THIS YEAR. IT IS THE RESULT OF A QUADRI-PARTY INTERNATIONAL AGREEMENT THAT WAS SIGNED BY U.S., CANADA, JAPAN, AND EUROPE. THEY COLLECTIVELY ENDORSED FFTF AS THE BEST REACTOR IN THE WORLD FOR FUSION MATERIALS TESTING. THE TEST ASSEMBLY IS COMPLEX AND A SUPERB TECHNICAL ACHIEVEMENT. FOR EXAMPLE, IT WILL BE TESTING FUSION MATERIALS FOR TRITIUM PRODUCTION, AND AS THE TRITIUM GAS IS GENERATED, IT WILL ACTUALLY BE COLLECTED AND MEASURED THROUGH FFTF'S UNIQUE INSTRUMENTATION AND GAS COLLECTION SYSTEM.

WE ARE ALSO PROPOSING TO TEAM WITH ORNL TO DESIGN AND TEST A LOW-TEMPERATURE REFRIGERATED TEST IN FFTF. THIS IS NECESSARY BECAUSE THE NEAREST-IN-TIME FUSION DEVICE WILL OPERATE AT LOWER TEMPERATURES. IF THIS TEST IS ACCEPTED, FFTF'S TESTING CAPABILITY WILL EXTEND FROM REFRIGERATED TO WHITE HOT TEMPERATURES -- AGAIN TRULY UNIQUE IN THE WORLD.

ISOTOPE PRODUCTION

OUR ISOTOPE PRODUCTION EFFORT IS IN ITS INFANCY. WE HAVE PRODUCED COBALT-60, BUT HAVE CONCLUDED THAT WE CANNOT BE THE LOW COST PRODUCER OF THIS ISOTOPE. WE HAVE GENERATED GD-153 OF VERY HIGH PURITY, AND ARE PREPARING TO SHIP IT TO ORNL FOR PROCESSING. WE HAVE IDENTIFIED A NUMBER OF OTHER ISOTOPES THAT CAN BE PRODUCED IN

FFTF FOR MEDICAL APPLICATIONS. OUR PLANS ARE TO WORK CLOSELY WITH ORNL, COMPLEMENTING HFIR AND UTILIZING THEIR TPP FACILITIES AND TECHNICAL EXPERTISE IN THE AREA OF SPECIALTY ISOTOPE PRODUCTION. BACKUP CF-252 PRODUCTION IN FFTF WITH REPROCESSING AT ORNL IS ESPECIALLY ATTRACTIVE. YOU MAY BE AWARE THAT THIS ISOTOPE IS THE KEY INGREDIENT TO A NEW DEVICE FOR DETECTING PLASTIC EXPLOSIVES IN AIRLINE BAGGAGE. WE HAVE HAD TEAMING MEETINGS AT THE LABORATORY DIRECTOR LEVEL, AND WE ARE CONFIDENT THAT WORKING TOGETHER WE CAN BETTER FULFILL THE GROWING NEEDS OF THE COUNTRY FOR SPECIALTY ISOTOPES.

WASTE BURN

LAST YEAR WE TESTIFIED THAT WE WERE EXCITED ABOUT THE CONCEPT OF TRANSMUTING NUCLEAR WASTE. WE HAVE PROPOSED TWO TESTS IN FFTF TO DEMONSTRATE KEY FEATURES OF THIS CONCEPT: (1) A RELATIVELY SIMPLE ACTINIDE BURN, AND (2) A MORE COMPLEX EPITHERMAL SPECTRUM BURN TO DESTROY KEY BAD ACTORS SUCH AS TECHNICIUM AND IODINE. FFTF IS THE ONLY DOE REACTOR LARGE ENOUGH TO CREATE A REPRESENTATIVE EPITHERMAL SPECTRUM OVER A REASONABLE VOLUME.

THE ADDITION OF A SIMPLE TRUEX TO THE SPACE ISOTOPE PROCESS LINE WOULD ALLOW A COST EFFECTIVE DEMONSTRATION OF THE PROCESSING SIDE OF THE WASTE BURN CONCEPT. ASIDE FROM THE REACTOR TESTS, HOWEVER, WHAT IS NEEDED MOST OF ALL IS A SOUND ECONOMIC AND ENVIRONMENTAL ANALYSIS OF THIS CONCEPT. ~~CAN IT BEAT THE CURRENT 1 MIL/KW COST TO THE UTILITIES? DOES IT ULTIMATELY REDUCE THE HAZARD TO THE ENVIRONMENT OR DOES THE EXISTENCE OF A PROCESSING FACILITY OF ANY KIND REPRESENT A HIGHER HAZARD THAN A SECOND REPOSITORY?~~ THIS IS AN AREA READILY PRONE TO INFLATED CLAIMS, AND A ~~GLOBAL~~ comprehensive ECONOMIC AND ENVIRONMENTAL HAZARDS ANALYSIS MUST BE THE NEXT STEP.

IN CONCLUSION TO MY TESTIMONY, FFTF/FMEF ARE THE MOST MODERN AND MOST RELIABLE SOURCES OF NEUTRONS IN DOE. THE ONLY WAY FISSION AND FUSION DEVELOPMENT CAN PROCEED UNDER THE COUNTRY'S DEFICIT CONDITION IS THROUGH TEAMING ACROSS SITES, AND NON-PAROCHIAL SHARING OF FACILITIES.

APPENDIX A

REDUCTION OF FACILITY COSTS FOR NUCLEAR ENERGY PROGRAMS

IN 1982 THE HANFORD LIQUID METAL REACTOR FUNDING WAS $181M. FROM 1981 TO 1989, HANFORD HAS SUFFERED EIGHT SUCCESSIVE YEARS OF FUNDING REDUCTIONS. OTHER SITES HAVE INCREASED IN FUNDING OVER THE SAME PERIOD. FFTF BEGAN OPERATIONS IN 1983. AT THAT TIME, THE LMR PROGRAM DIRECT STAFF WAS 1258. THIS STAFF WAS CONTINUOUSLY REDUCED IN A DISCIPLINED, CONTROLLED MANNER IN A STEP-BY-STEP IMPROVEMENT IN OPERATIONS. BY 1988 WE REACHED A DIRECT STAFFING LEVEL OF 544 PEOPLE.

WE HAVE COMPARED OUR REACTOR TO OTHER U.S. AND INTERNATIONAL OPERATIONS AND HAVE CONCLUDED THAT OUR CURRENT STAFFING LEVEL IS CORRECT. WE WERE BORN UNDER THE DISCIPLINE OF NRC REVIEWS AND OPERATION TO THOSE STANDARDS. WE ALSO USE THE INSTITUTE OF NUCLEAR POWER OPERATIONS (INPO) STANDARDS AS A BASIS OF COMPARISON WHEN APPLICABLE.

WE ENDORSE THE NEED FOR MORE FUNDS FOR TECHNOLOGY, BUT TO REMOVE THEM FROM AN OPERATING NUCLEAR REACTOR IS CLEARLY NOT WISE.

THE FUNDING LEVEL FOR OUR FACILITIES APPEARS TO HAVE JUMPED FROM $70M TO $101M. IN FACT, THAT IS REALLY THREE EFFECTS OVERLAID, ALL OF WHICH ARE DUE TO EXTERNAL FACTORS THAT WE DO NOT CONTROL, FIRST, THE DEPARTMENT OF DEFENSE WILL NO LONGER BE ABLE TO PROVIDE PLUTONIUM-239 FOR OUR FUEL. THIS FORCES US TO DO A CORE TRANSITION TO ENRICHED URANIUM. CHANGING CORES IN A 400 MW OPERATING NUCLEAR REACTOR IS NOT SOMETHING TO BE TAKEN LIGHTLY. WE ARE PROCEEDING WITH THE NECESSARY TESTING AND ANALYSIS TO PROVE THAT WE WILL BE WELL WITHIN OUR CURRENT SAFETY ENVELOPE AFTER THE TRANSITION. THIS WILL ALL BE REVIEWED BY INDEPENDENT BODIES. THIS CORE

TRANSITION COST IS $34M, STARTING THIS YEAR AND ENDING IN JULY 1991.

SECONDLY, THE NATIONAL ACADEMY OF SCIENCES AND THE ADVISORY COMMITTEE ON NUCLEAR FACILITY SAFETY PROVIDED SUGGESTIONS TO FURTHER IMPROVE THE SAFETY OF OUR OPERATIONS. THIS INCLUDED CONDUCTING A PROBABILISTIC RISK ASSESSMENT AND UPGRADING OUR TRAINING SIMULATOR. THE DEPARTMENT OF ENERGY AGREED WITH THESE SUGGESTIONS AND COMMITTED US TO PROCEED. THE ESTIMATED COSTS FOR THESE ITEMS ARE $7M FROM 1989 TO 1991.

THIRDLY, DOE HAS CHANGED THEIR POLICY ON THE URANIUM ENRICHMENT PROGRAM. STARTING IN 1990, THEY WILL START CHARGING FOR SWU'S FOR OUR FUEL. WE HAVE BEEN INFORMED THAT THIS WILL COST $14M A YEAR.

DOE HAS ADVISED US TO PROCEED WITH THE FIRST TWO ITEMS AT THIS TIME. AND OUR UNDERSTANDING IS THAT A REPROGRAMMING LETTER TO THAT EFFECT IS IN OMB AT THIS TIME. OUR DOE APPROVED BASE IN 1989 WOULD BE NEAR $80M, WHICH IS VERY CONSISTENT WITH OUR PROJECTED NEEDS IN 1989 IN OUR TESTIMONY TO YOU LAST YEAR.

ALSO, PLEASE NOTE THAT THESE FIRST TWO ACTIVITIES WILL BE COMPLETED BY 1991. SO IN 1992, THE COSTS WILL DECREASE BY APPROXIMATELY $10M.

IF THE LAST PHASE OF THE PLUTONIUM-238 SPACE ISOTOPE PROGRAM IS COMPLETED, I.E., THE FUEL REPROCESSING PHASE, OUR SWU COSTS IN 1995 WILL BE SEVERELY REDUCED BECAUSE WE WILL HAVE CLOSED OUR FUEL CYCLE.

CONSTRUCTIVELY, HOW CAN WE REDUCE OUR FACILITY COSTS TO THE NUCLEAR ENERGY PROGRAMS:

> FIRST, EMBRACE THE PLUTONIUM-238 MISSION FOR FFTF. IF THIS PROCEEDS BY 1994, WE WILL PRODUCE PLUTONIUM-238 AT A

COMPETITIVE COST AND WILL BE ABLE TO REDUCE THE COSTS TO ALL OF OUR IRRADIATION CUSTOMERS BY 50 PERCENT.

SECOND, SUPPORT OUR OTHER ISOTOPE TEAMING EFFORT WITH ORNL AND SUPPORT THE POWER ADDITION PROJECT THROUGH SUPPORTING THE CONTINUED OPERATION OF THE FFTF. TOGETHER, WHEN IMPLEMENTED, THEY WILL REDUCE OUR FACILITY COSTS TO DOE BY ANOTHER $10M.

THIRD, SUPPORT FFTF AS THE LONG-TERM CORNERSTONE TEST REACTOR FOR FISSION AND FUSION PROGRAMS. THIS WILL ENABLE US TO PROCEED WITH FURTHER GOOD FAITH NEGOTIATIONS FOR EXPANDED INTERNATIONAL TESTING. THE AMOUNT OF SUPPORT OUR INTERNATIONAL FRIENDS CAN PROVIDE IS UNKNOWN AT THIS TIME, BUT A $30M PROGRAM OVER SIX YEARS IS BEING CONSIDERED BY JAPAN.

FOURTH, LOOK FOR SYNERGIES AMONG PROGRAMS TO MINIMIZE COSTS TO ANY ONE PROGRAM OR PROGRAM ELEMENT.

FIFTH, ENCOURAGE A TEAMING STRATEGY WHEREIN ALL SITES UTILIZE EACH OTHER'S FACILITIES.

SIXTH, MAKE GOOD USE OF MODERN FACILITIES THAT CAN OPERATE TO YEAR 2000 AND BEYOND WITHOUT MAJOR UPGRADES.

APPENDIX B
SP-100 GROUND ENGINEERING TEST SITE

THE SP-100 GROUND ENGINEERING TEST CONTINUES TO BE THE SHOWPIECE OF THE PROGRAM. THIS PAST YEAR SIGNIFICANT PROGRESS WAS MADE ON ASSURING THE REACTOR TEST WOULD BE CONDUCTED IN ACCORDANCE WITH TODAY'S STANDARDS AND PRACTICES. WE HAVE COMPLETED 20% OF THE TEST SITE DEFINITIVE DESIGN AND HAVE REFURBISHED ALL THE SURPLUS LIQUID METAL EQUIPMENT BEING TRANSFERRED FROM FFTF TO SP-100. WE HAVE DEVELOPED A CLOSE WORKING RELATIONSHIP WITH THE SYSTEM CONTRACTOR, INCLUDING AN INTEGRATED WORK SCHEDULE AND CLEARLY DEFINED INTERFACE CONTROLS. THE ENVIRONMENTAL ASSESSMENT WAS COMPLETED AND PUBLISHED IN THE FEDERAL REGISTER. FINALLY, WE COMPLETED A PRELIMINARY SAFETY ANALYSIS REPORT WHICH IS CURRENTLY UNDERGOING PROJECT REVIEW. TO SUMMARIZE, WE ARE ON SCHEDULE TO ALLOW CONSTRUCTION TO BEGIN IN EARLY 1990.

WE ARE CONTINUOUSLY BEING FORCED TO ACCOMMODATE FUNDING REDUCTIONS AS HAVE OUR TEAM MEMBERS IN THIS PROGRAM. THE DEPARTMENT OF ENERGY HAS DONE A VERY CREDIBLE JOB IN KEEPING THIS PROGRAM ON TRACK, BUT I'M AFRAID THE TOTAL PROGRAM IS NEAR ITS BREAKING POINT. AT GES, WE ARE IN A CRITICAL STAGE OF VACUUM VESSEL PROCUREMENT. IF THIS GETS DELAYED, OUR MONTHS OF CAREFUL PROCUREMENT WORK WILL BE WASTED. ON THE OTHER HAND, THERE MUST BE ENOUGH FUNDS TO DESIGN AND BUILD THE REACTOR. THIS IS THE TIME TO REAFFIRM OUR COMMITMENT TO THE NATIONAL NEED TO DEVELOP THIS POWER SOURCE FOR SPACE. IF THIS PROGRAM'S FUNDING ERODES AND DIES A DEATH OF 1000 CUTS, IT WILL BE ANOTHER DEMONSTRATION OF A LACK OF NATIONAL RESOLVE. IRONICALLY, if this should occur DOE WILL PROBABLY BE BLAMED FOR "MISMANAGEMENT" OF THE PROGRAM AND NOTHING COULD BE FARTHER FROM THE TRUTH.

PANEL 1 DISCUSSION

Mr. **Stallings**. Mr. Morrison, would you like to begin the questioning?

Mr. **Morrison**. Thank you, Mr. Chairman.

I am very proud of the record of FFTF and I am pleased, Dr. Korenko, that you chose to make the case for Plutonium 238. I wish Admiral Watkins was here and part of that new team that will be actually making that decision.

I note with some interest some discussions of waste burn, and that's something we have been working on for a number of years. Could you describe the CURE project as you have advanced it in the past and how it might relate to the process described by Dr. Chang?

Dr. **Korenko**. I think the similarities occur on the reactor side, actually the reactor burning of the waste. There are really two types of waste that we like to destroy. One is called the actinides, and that is not necessarily really a big deal to burn actinides. We burn actinides all the time. Plutonium is an actinide. It is necessary to burn the remains of actinides, but that will just be effectively fuel for a reactor.

The difficult side is our proposed, what we call the epithermal burn, where we actually take the fast neutrons in a reactor and slow them down a bit. By slowing them down, that puts them right in a range where they can destroy the key bad actors that really cause problems; for example, technetium and iodine.

The test that we are proposing really has to be done in FFTF because it has a large enough size to put the yttrium hydride in, necessary to produce this modified spectrum, and that is the commonality between the processes.

The differences are that we would, for CURE, are proposing digesting the spent fuel in an oxide dissolution process, a Purex/Truex process, in the IFR suggestion using pyroprocessing. But there are a lot of similarities as well as differences.

Mr. **Morrison**. I think it's an exciting concept that perhaps has even been held back by not wanting to divert us from the goal of finding that long-term repository, but I think this Subcommittee would be very interested in proceeding with this program.

I would also like to ask you, Dr. Korenko, there has been a growing concern over facility operation costs, and as we get the budget squeeze, people keep looking at that.

Do you have any suggestions on how you reduce these costs? I know it's a concern at FFTF.

Dr. **Korenko**. Yes, I do. First, I mentioned in my testimony that supporting the Pu–238 mission is a neat way to reduce facility costs because that effectively removes half of our facility costs in the year 1994.

Similarly, we ought to pursue other work at the facility that effectively takes us off budget. For example, the power addition to FFTF will reduce $6.0 million a year from our facility costs and demonstrate the key Clinch River reactor components.

We've been at Oak Ridge looking for teaming in the other isotopes such as medical isotopes, and that could also take facility costs. So that is one category of cost reductions.

I think there's another way, what we call two-for-one specials. I hate to use that. But it's the matter of looking at different ways to use the facilities that actually demonstrate technology. As an example, we recently traveled to General Electric and looked at the PRISM components that would be necessary for future demonstration. As FFTF goes through its regular upgrades, it will have to be replacing components as a function of time. So we are taking our component list that needs to be replaced and comparing it with the PRISM component list and see if we can do what we call a two-for-one special where you can replace it with a PRISM type component while you're upgrading.

So learning to think smarter like that is an example of, if you want, how to use the facility to demonstrate directly technology.

A third thought is that we really ought to continue the thrust for team work together from lab to lab, site to site, because we have facilities that are expensive and we need to support each other's facilities and each other's expertise.

As an example, we teamed very closely with Los Alamos in the SP-100 efforts, and Oak Ridge in the isotope area, using their TPP facilities at Oak Ridge.

Finally, I think we ought to think long term. We have to look at which facilities will be around in the year 2000 and think back from the long term, rather than think short term and end up in a wrong direction.

I might add that if we were assured that FFTF had a long-term mission, then we could negotiate in good faith with our international partners, because until that is satisfied, we have a $30 million proposal on the table that we can't in good faith really discuss until our future is more secure.

Mr. MORRISON. Thank you very much.

Thank you, Mr. Chairman.

Mr. STALLINGS. Mr. Schiff?

Mr. SCHIFF. Mr. Chairman, as a new Member of the Committee and the Congress, I have no comments. I am just drinking it all in. I have no questions. I just want to thank the panel.

Mr. STALLINGS. Thank you.

Dr. Chang, I missed Mr. Fawell's introduction of you, but I certainly welcome you here. As you're well aware, we share a common concern and that is Argonne West and some of the exciting things that your folks are doing in my district.

Could you give me a personal impression or a personal view of yours regarding the IFR? I know that you delivered a testimony here today based upon your work for the last few years. Very briefly, what is your impression of this concept?

Dr. CHANG. As I discussed during my testimony, we believe, we at Argonne firmly believe this is a major technological breakthrough which will provide a real advanced reactor concept for the next generation which satisfies all three fundamental requirements I mentioned; namely, the breeding that will supply the unlimited energy, almost as good as a renewable energy source; second, the inherent safety which is necessary to have widespread deployment of nuclear power; and the third one, finally, is the solution to the long-term high-level waste disposal.

With those three requirements satisfied with the IFR concept, we believe this will be a major technological breakthrough if this technology is fully developed and demonstrated.

Mr. STALLINGS. Does the Department of Energy agree with that assessment?

Dr. CHANG. Yes. That is why DOE is putting a high priority on the IFR concept development as part of their advanced reactor development program.

Mr. STALLINGS. A couple of years ago, they sent over in their documents, a statement saying that the IFR would be the focal point of their future scientific endeavor; that it was a tremendous program and they certainly were going to pursue it with all of their energies.

And yet when we got the budget numbers for that project, it was zero. I worry about that kind of commitment.

Now, you mentioned a precipitous drop in the funding for the IFR program in fiscal year 1990. In your opinion, what will happen if the program receives only the $6.1 million requested by the Department of Energy?

Dr. CHANG. The reduction of $23 million would bring a halt to the forward progress of all of the major IFR development tasks. In particular, the refurbishment of the original EBR-II fuel cycle facility, which is now called the HFEF South, is a major task which involves the process scaleup from a glove box operation with the unirradiated uranium to a plant scale remote operation with actual irradiated fuel from EBR-II.

This important mission of the IFR fuel cycle demonstration represents a substantial work scope increase in FY 1990 compared to FY 1989, and this task could not be accomplished on schedule without the necessary funding restoration.

Mr. STALLINGS. If the IFR is as significant, as important as you believe and apparently they believe, why are they submitting these ridiculously low funding numbers?

Dr. CHANG. I cannot answer for the Department of Energy.

Mr. STALLINGS. I'm not sure anyone can at this point.

Dr. CHANG. I believe this was a result of a severe budget cut dictated by the OMB.

Mr. STALLINGS. It seems to me that one of the problems that we've been facing the last few years is a lack of an energy policy in this country, the lack of any real direction, and it seems to me we're doing some hit and miss spending with OMB being the driving force behind a lot of what we're doing and that, as a result, our dollars are not necessarily going to the best projects with the long-term benefits but to what seems to be convenient at the time.

I certainly congratulate you and Argonne in the development of this project. I was at the Idaho facility just after they shut off the machine, to see what would happen if that in fact were to happen. They were excited and I was excited because the results—and I thought the timing was excellent—because about that same time, Chernobyl had their accident which that really brought what your folks had done into focus.

I think that with that machine, we have a potential for resolving a lot of our problems in this country, not only the three that you mentioned but also something to do with this greenhouse effect that we seem to be suffering from.

I would hope that the Department under Admiral Watkins—and we're all eagerly waiting his confirmation and then getting to work and developing both energy policies and developing the kinds of direction that we need—and so when they say the IFR is the centerpiece of their programs, that they will also put the money in the budget to make their words mean something.

I appreciate this panel's participation. I would hope, gentlemen, if our Chairman or any other Member wants to send you some questions, that you would be willing to respond to those questions. I know there were several Members that wanted to be here today but were not able to because of other commitments.

With that, I thank you for your time and testimony, unless, Mr. Morrison, you have anything else you would like to raise at this point?

Mr. MORRISON. No.

Mr. STALLINGS. We will excuse this panel with the Committee's thanks for your excellent testimony.

Our second panel in today's session is composed of three members. Dr. Bertram Wolfe, the Vice President and General Manager for G.E. Nuclear Energy is our first witness. Dr. Wolfe is a familiar face and we welcome him before this Subcommittee.

Also participating in this panel will be Dr. Shelby T. Brewer of Combustion Engineering and Dr. Clark Gibbs of Rockville International Corporation.

Dr. Wolfe, if you would like to begin, we'll introduce the other two gentlemen as they begin their testimony.

PANEL 2

STATEMENT OF DR. BERTRAM WOLFE, VICE PRESIDENT AND GENERAL MANAGER, GENERAL ELECTRIC CO.

Dr. WOLFE. Mr. Chairman, I am delighted to be back again. As you say, I have been here several times.

In my written statement I cover nuclear energy in some broad aspects, and what I would like to do today because of the time you've given us verbally is to restrict my comments to three programs in which General Electric specifically is involved.

One of them builds on the Advanced Boiling Water Reactor which was mentioned before. The largest private utility in Japan, Tokyo Electric Power, has ordered two ABWRs for commercial startup in 1996 and 1998. They will be built by General Electric, Toshiba, and Hitachi, with G.E. being responsible for the steam supply system, the nuclear fuel and the turbine generators for both of the 1,350 megawatt electric plants.

The ABWR is a key element in G.E.'s part of the Advanced Light Water Reactor design certification program which Mr. Stello talked about a little while ago, and that's a program initiated by the Department of Energy and EPRI and approved by Congress in 1987.

The program would in effect lead to prelicensed U.S. nuclear plants and could lead to five-year construction times, or perhaps even four years which are common abroad, rather than the unaffordable 10 to 15 years now common here.

The results to date from the DOE/G.E./EPRI program for regulatory review of the total ABWR plant—that's the total plant—by the NRC have been excellent and the program is on schedule for the 1991 regulatory certification of the design. Incidentally, that's the same time schedule that MITI in Japan has for giving their standardized approval.

Let me read just a statement from Mr. Lando Zech at the last full Commission meeting of the NRC several weeks ago, who went over the work to date on the ABWR certification and ended up saying, "I ask you to keep up the good work. We think that the standardization and certification process is the future of nuclear energy in our country and certainly what you have done I think is very responsive to the Commission's suggestions and directions. Again, I commend you for what you have done."

I agree with Commissioner Zech. If we don't get standardized licensing in this country, we might as well give up on nuclear power.

A second program sponsored by EPRI and DOE with your support is to develop smaller Advanced Light Water Reactor plants with enhanced safety features. And under this program, our part, G.E.'s part is developing the Simplified Boiling Water Reactor, the SBWR. The results have been so promising to date that DOE has issued a request for proposal for the next phase of this development program, leading to regulatory certification by 1995.

And we intend to respond to this cost-share program which will require consistent government and private sector support if it's to be successful, the point that you have made several times, Mr. Stallings.

The Light Water Reactor is clearly the technology of choice for the near term. Although there appears to be sufficient uranium to supply LWRs for at least several decades or more, the real promise of energy security through nuclear power is an unlimited energy supply through the breeder reactor, possibly an urgent need if the greenhouse effect is real.

In addition to unlimited fuel supply, the current studies show a potential nearer term benefit of the breeder in the form of enhanced nuclear waste management which has been mentioned by the previous testifiers. The breeder has the fuel recycle capability to eliminate not only the long-life actinides in its wastestream, but there are ways in which we could use the breeder to reduce the long-term actinides in the Light Water Reactor wastestream.

The current DOE breeder program is based on the present concept initiated by G.E. in 1981 and is being carried forward by a results-focused industrial team utilizing the complementary skills of General Electric, Westinghouse, Bechtel, Burns and Roe, United Engineers and Constructors, Babcock and Wilcox, and others, thus assuring a competitive industry capability for commercial application when needed in the next century.

I might note that the ALMR, the Advanced Liquid Metal Reactor, the breeder design that we are using, the one that won the recent competition as indicated above, uses the metal fuel under development by Argonne which you heard about in the last panel in its IFR program. So this is part of that whole program. The interaction of the fuel and the reactor design allows for the inherent shutdown characteristics of the system and provides passive emergency decayed heat removal and protects public safety and investment.

In my written testimony I go through those characteristics in more detail.

We have achieved this focused program since 1985 through multiple design competitions which have led to a five-year cost-sharing industrial team contract, just signed by the Department of Energy in January of this year, a month ago. However, the fiscal 1990 requested funds by DOE for design and technology support are inconsistent with the contract and program plans and are insufficient to carry on this successful program. Thus, we ask for your support to restore the appropriate funding to this program.

And I hate to take issue with my good friend Jerry Griffith who talked on the previous panel, but our view is that in going down to the $4.0 million, from the $16 million to the $4.0 million, we have essentially a stand-still program.

Let me conclude by just saying that none of us can be sure how much we can rely on fossil fuels in the future. Nuclear power could be a vital factor to help assure future energy security, but this assurance is far from certain today in the United States.

Industry and government will have failed the American people if we do not place a meaningful nuclear option before them. We will adversely affect our foreign policy, nonproliferation policy, if we give up technological leadership in nuclear power development. And for these reasons, we urge the Committee to support the necessary key programs such as those that I discussed above.

Thank you very much.

Mr. STALLINGS. Thank you, Dr. Wolfe, for your excellent testimony.

[The prepared statement of Dr. Bertram Wolfe follows:]

TESTIMONY OF

BERTRAM WOLFE
VICE PRESIDENT AND GENERAL MANAGER
NUCLEAR ENERGY OPERATION
GENERAL ELECTRIC COMPANY

ON

CIVILIAN REACTOR RESEARCH AND DEVELOPMENT PROGRAMS

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

MARCH 1, 1989

My name is Bertram Wolfe and I am Vice President and General Manager of General Electric's Nuclear Energy Operation. I have been actively involved in the research, development and application of nuclear power generation for over 30 years. I am a past president of the American Nuclear Society, a member of the National Academy of Engineering and am on the board of several industry organizations in the nuclear energy field. Over the past years I have presented testimony to this Subcommittee during a period when the ability to meet future U.S. energy needs with nuclear power has been waning. All nuclear plants in the U.S. ordered after 1973 have been canceled and utility executives freely state that, under today's conditions, they would not commit to a new nuclear project. My testimony today is not intended to argue for a program for building new nuclear plants. Rather, I want to strongly suggest that it would be a failure on our part, both government and industry, and a grave and dangerous disservice to the American public if we did not maintain nuclear power as a meaningful option for the United States in our increasingly uncertain energy future. Fortunately, there are some ongoing programs with positive results to-date which have had your support in the past. With your continued support, these results oriented programs will make this important, perhaps vital, energy source an available and acceptable option for our future.

Nuclear power continues to be the only economic alternative to an excessive reliance on fossil fuels. Yes, there have been growth pains, but our industry is only about 35 years old and during this period we have built and are now operating over 350 nuclear plants worldwide. Last year in the United States, nuclear power produced over 500 billion kilowatt hours (kwh) of electricity, about equal to our total electric power generation only 35 years ago; and this nuclear power production continued the perfect U.S. safety record of no radiation injuries or deaths due to nuclear power. Last year the world's nuclear generation of electricity displaced the consumption of over one and a half billion barrels of oil. This is particularly important to the long term energy security of the United States as our importation of oil has increased to the point where we now exceed import levels existing before the oil embargo of 1973 and our importation is projected to increase to even higher levels in the future. Indeed oil companies and the American Petroleum Institute warn that on our present course, OPEC in the 90s is apt to be stronger than OPEC in the 70s.

Last year worldwide nuclear power generation reduced the discharge of CO_2 into the atmosphere by over a billion tons or about half the CO_2 discharged by all U.S. fossil fired plants. Our recent weather patterns and lack of normal rainfall have raised new questions and concerns of global warming and the greenhouse effect. If the greenhouse effect proves to be a real environmental problem, certainly use of nuclear power is one of our prime choices for major ameliorating action.

I believe it is also important to recognize that the success of the U.S. non proliferation policy in the past was due to our technical leadership that allowed us to constructively influence nuclear energy development and use in peaceful directions. Indeed, some seem to have forgotten that the intent of President Eisenhower's Atoms for Peace program was not nuclear power for the U.S. but rather international nuclear technology leadership by the U.S. so that the widespread international movement toward nuclear weapons could be redirected. If we hope to continue such leadership, we must provide consistent support to key programs aimed at timely advanced reactor development and build upon the excellent results in these programs to-date. Otherwise the U.S. will send a message to the world that it is giving up its nuclear power leadership role. I might note that this will not only adversely effect our foreign policy (nonproliferation) objectives, but will also undermine and erode U.S. industrial capability to maintain the significant, current, positive trade balance in this industry.

Let me now turn to specific key programs and their positive results. As indicated in my introduction, the past decade led to an environment not supportive of the development and construction of improved reactors in the U.S. Over this period, some U.S. reactor manufacturers have continued to make significant technological improvements by working with overseas partners and customers where the environment for nuclear power is more favorable. These partners and their governments have recognized the value of this U.S. industrial capability and maintained their long standing relationships in the development of advanced designs. Such was the case for GE and its international partners in the development of the Advanced Boiling Water Reactor (ABWR). This development effort, which has spanned over 10 years, has resulted in an advanced reactor design which takes advantage of 30 years of BWR experience. Its advanced features have been fully tested in a development program costing in excess of a quarter of a billion dollars. The largest private utility in Japan, Tokyo Electric Power Co., has ordered two such plants for commercial startup in 1996 and 1998. General Electric is a key member of the industrial joint venture supplying these plants; GE being responsible for the nuclear island, nuclear fuel and turbine generators for both 1350 MWe plants. Hitachi and Toshiba are partners in this venture and will have responsibility for the balance of the plant. The technology incorporated in these plant designs reflects state of the art technology applied in an evolutionary progression of the extensive BWR experience base.

The ALWR design certification program initiated by DOE and approved by Congress in 1987 is a major step forward to adopting the advanced light water reactor designs, such as ABWR, for the United States. This government program, in conjunction with the Electric Power Research Institute (EPRI) requirements program and the advanced designs provided by industry, can provide the basis necessary to achieve regulatory certification of modern standard designs that will help to effectively control the excessive costs and schedules now associated with U.S. nuclear plants.

The results to-date from the DOE-GE program for regulatory review of the total ABWR plant by the NRC have been excellent and the program is on schedule for the targeted 1991 regulatory certification of the design. It is hard to overemphasize the government leadership and dedication necessary to successfully complete a meaningful standardization and certification program. We are confident, from a technical standpoint, that this can be done. We see positive indications that the chapter by chapter regulatory review is leading towards a final design approval and the public hearing process that will provide for ABWR certification and the proof that we have the institutional means to enjoy the benefits of safe nuclear power. This key program stands as a forerunner to all other advanced reactor development programs as it establishes the requirements for standardization and regulatory certification. It is a program which requires modest, but important, near term government support to complete its focused objectives. I believe incidentally, that success of this standardized plant approach would be greatly aided by future nuclear licensing legislation affirming congressional support of the approach.

We believe it will also be advantageous in the future to economically be able to deploy advanced nuclear plants in increments of 500-600 MWe. Such designs should benefit from existing advanced light water reactor technology, such as described above, but must also benefit from enhanced features such as simpler, more passive safety features and natural coolant circulation which offset the diseconomy of scale affecting such midsize systems. To this end EPRI and DOE, with your support, initiated a development program that is providing the type of data necessary to assess the performance of such features and support design completion and regulatory certification. The results to-date on these feature tests applicable to the 600 MWe Simplified Boiling Water Reactor (SBWR) have been very positive and support further development.

DOE has issued a Request for Proposal for the next phase of this evolutionary advanced reactor development program leading to regulatory certification by 1995 and technical readiness for commercial deployment in the late 1990s. This key program is based on a cost sharing approach by the private sector, including contributions from international partnerships. Indeed, we have significant interest in the SBWR from our associates abroad. Such cost shared programs require consistent government and private sector support if they are to be successful.

The light water reactor (LWR) is clearly the technology of choice for the near term. It has received extensive development and has a well established 30 year industrial infrastructure and experience base. We commend the Department of Energy and Congress for their insight in establishing these important programs and fully support their continuation to completion. If successful, these efforts will go a long way toward reestablishing the U.S. nuclear option and could restore industry's confidence in the nuclear market.

The revival of the LWR in the U.S. and its widespread use throughout the world raises the issue of the long term future of nuclear power. The LWR systems rely on the economic availability of a finite resource, uranium. Although there appears to be sufficient uranium to supply LWRs for at least several decades, the real promise of energy security through nuclear power is an unlimited energy supply through the breeder reactor - possibly an urgent need if the greenhouse effect is real.

The development and demonstration of an economic advanced liquid metal reactor (ALMR) design continues as a key ongoing effort internationally. The ALMR, once fueled, can continue to maintain its capacity with essentially no new uranium supplies, thus providing the highest most efficient use of uranium resources. Introduction of the ALMR can eliminate the uncertainty over future uranium supply and assure that nuclear power can maintain essentially any level of economic capacity that may be required. This has been the promise of the liquid metal reactor development since the early introduction of nuclear power and continues to be its long term goal. While this capability alone justifies continued, timely development of the ALMR, current studies show a potential nearer term benefit in the form of enhanced nuclear waste management. This is because the ALMR has the fuel recycle capability to eliminate the long life high level actinides of its own waste stream and can be further utilized to similarly utilize the discharged fuel from the water reactors.

The current DOE program for development of an innovative ALMR was initiated in 1985 and has utilized a series of competitive awards leading to selection, in July 1988, of a single national design for further development. This design based on the PRISM concept, initiated by GE in 1981, is being carried forward by a results focused industrial team utilizing the complementary skills of General Electric, Westinghouse, Bechtel, Burns & Roe, United Engineers and Constructors, Babcock and Wilcox, Foster Wheeler and Borg Warner; thus assuring a competitive industry capability for commercial application when needed in the next century.

This ALMR design emphasizes a low pressure pool type modular reactor system enhanced by passive and inherent safety features, modular construction with maximum factory fabrication, seismic isolation for wider site acceptability and multiple module capabilities for improved operability and availability. The plant is based on using a number of standardized reactor modules, fabricated in a factory and shipped by whatever combination of barge, rail or road transport is most economic for a particular site. The target commercial product utilizes three reactor modules in standardized power blocks of 465 MWe and since each power block operates independently, plant size flexibility is provided to the utilities to minimize investment risk and enhance the ability to meet uncertainty in power demand growth.

This ALMR design uses the metal fuel under development by Argonne National Laboratory (ANL) in its IFR program. The interaction of fuel and reactor design, providing excellent negative reactivity feedback, allows for the inherent shutdown characteristics of this ALMR system. This negative feedback coupled with the passive, always operating emergency decay heat removal system provides excellent response to potential off normal conditions such that public safety and investment protection are provided through self-regulation, even without operator intervention. Additionally, the potential cost advantages from the fuel recycle system and simplified safety features provides for attractive economics that are competitive with future alternative energy sources. While it's still early in the development process, the cost projections have been extensively reviewed by a DOE led peer review team and are felt to be representative of the potential of the ALMR system.

As stated earlier the ALMR system provides capability for enhanced waste management. Not only does the modular approach to the ALMR permit component replacement as necessary, but also reduces the volume of replaced components required for alternate plant designs of larger size. Further, the sodium coolant in the ALMR precludes crud buildup resulting in factors of two to four times less waste volume and two to three orders of magnitude less curies per unit of power produced for ultimate waste disposal.

Perhaps the most important waste management enhancement, however, is the opportunity for improvement in waste from the fuel cycle as a result of the reference metal fuel pyroprocess being developed by ANL. Not only are waste volumes reduced through smaller process streams and fewer process steps, but importantly the long life high level waste actinides are processed with the recycled plutonium and uranium for reuse as fuel in the reactor. Assuming the actinides are transferred with the fuel, this can reduce the high level waste storage requirement from millions to hundreds of years. This same capability applied to LWR spent fuel together with the ALMR reactor capability to burn the recycled fuel and actinides as startup fuel without significant technical or economic impacts offers an attractive waste management option for the U.S. Timely deployment of the ALMR system in concert with a viable ALWR nuclear option could provide an enhanced overall energy system approach.

We have achieved a focused LMR program via the competitive process. The industrial team, in concert with the national labs, ANL, ETEC, WHC and ORNL, providing key technology development, has proposed a multiyear plan for development and full scale prototypic testing of the ALMR to support regulatory certification. This plan builds on the five year cost sharing industrial team contract just signed by DOE in January 1989. It includes an aggressive private sector partnership and cost share, and also includes continued international participation in the development and test program. The overall program, however, cannot be successful without government support in the near term consistent with the DOE contract. The Fiscal 1990 requested funds for the ALMR design and technology support are inconsistent with the contract and insufficient to continue this successful program. We must ask for your support to restore appropriate funding to this program.

In conclusion, it is likely that the demand for electricity will continue to grow. The world petroleum problem over the long term is apt to get worse, not better. None of us can be sure of how long we can rely on fossil fuels as the predominant source of our energy supply. Nuclear power could be a vital factor in assuring future energy security but this assurance is far from certain today.

I believe there are three basic elements for a successful future national nuclear power program. First, the near term maintenance of the nuclear option should be pursued through efforts leading to the regulatory certification of standardized advanced LWR designs. Second, and the subject of another hearing, we must get on with a successful waste disposal program. This will have the dual effect of aiding in the public acceptance of nuclear power and demonstrating and exerting U.S. international leadership. And finally, for the longer term, and for continued international leadership, we should proceed with the demonstration and certification of the ALMR concept to assure these plants can be constructed and operated with user confidence and public acceptance and be technically ready for application when needed for U.S. energy security and/or waste management enhancement.

Industry and government will have failed the American people if we do not place a meaningful nuclear option before them. To this end we urge the Committee to support the key programs discussed above.

DR. BERTRAM WOLFE

Vice President and General Manager
GE Nuclear Energy

Dr. Wolfe received his B.A. in Physics from Princeton University in 1950 and his Ph.D. from Cornell University in 1954. He has been in the nuclear energy field since 1955, spending all but two years at General Electric. Dr. Wolfe has worked in almost all phases of nuclear energy from reactor design to fuel supply to waste management to development of new reactor concepts. He is Vice President and General Manager of GE Nuclear Energy, responsible for all GE activities in the nuclear power industry. He is a member of the Board of Directors of the Nuclear Management & Resources Council, U.S. Council for Energy Awareness, Nuclear Power Oversight Committee, and the American Nuclear Energy Council. He is a Fellow of the American Nuclear Society and in 1985 was elected Vice-President, President-Elect. He served as President for the year starting in June of 1986. Dr. Wolfe is a professional Engineer in the State of California, and is a member of the National Academy of Engineering. He holds a number of patents in the nuclear field and is the author of several dozen publications concerning nuclear technology, nuclear energy and energy in general.

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The next member of the panel is Dr. Shelby T. Brewer, the President of Nuclear Power Businesses of Combustion Engineering Corporation. Dr. Brewer is a welcome participant to our proceedings today and comes to us with a valuable store of knowledge on these programs because of his past role as Assistant Secretary for Nuclear Energy at the Department of Energy.

Dr. Brewer, we welcome you here today and look forward to your testimony.

STATEMENT OF DR. SHELBY T. BREWER, PRESIDENT, NUCLEAR POWER BUSINESSES COMBUSTION ENGINEERING, INC.

Dr. **Brewer**. Thank you, Mr. Chairman. It is, of course, a pleasure to be back. I have a written statement which I will submit for the record and summarize orally the main points in that statement.

Mr. **Stallings**. Thank you, Dr. Brewer. Your entire testimony will be made part of the record.

Dr. **Brewer**. As you know, Mr. Chairman, the problems facing nuclear power since the mid-1970s, since the nuclear recession set in in the 1970s, are largely institutional in character. They are less technical than they are institutional.

There are about six major factors that came into being in the mid-1970s that led to this recession. The first thing was the economy in general. It was a high inflationary economy, high interest rates. These two factors exacerbated the long construction times that plants were experiencing and drove up the capital costs of those plants.

In addition, the utility sector was transitioning from a capital surplus and a rate reduction era to capital deficits and rate increases. So more and more and more political pressure from the PUCs was placed on the system and new orders simply did not come along after 1973.

A third factor, of course, was that the utility sector was overcommitted. There was a large capacity overhang. They had simply ordered more than the load turned out to justify after OPEC.

Finally, the two other factors which led to the recession were the chaotic and undisciplined licensing process that was in effect in those days and the lack of standardization. We had a plethora of custom-designed light water reactors, custom-designed and custom regulated.

Now, many of these factors or circumstances have abated. For example, the load growth is back; the economy has been corrected; we no longer have a high-inflation, high interest rate economy; and a lot of things have happened on the positive side to give us some hope that nuclear power will again be deployed in this country—that is, new capacity will be deployed.

But what needs crucial attention now is standardization and regulatory reform, and everyone today has said that. We need to standardize the product, we need standard designs, and we need to standardize the process, the regulatory process.

Of all of the meritorious reactor programs sponsored by the Department of Energy, I regard the Design Certification program as the top priority because it goes to the very heart of the institutional barriers to further deployment of nuclear power in the United States.

The program is not a technology development program and its cost therefore is minimal compared to other DOE programs. It is not a plant demonstration project aimed at demonstrating a new technology. It is instead an institutional demonstration. In demonstrating a rationalized, streamlined regulatory process, a process that in fact better protects human health and safety as well as restoring confidence in the nuclear power option as a viable economic option among utilities and their investors.

Prelicensed standardized designs and some form of one-step licensing are absolute prerequisites to further deployment of nuclear power in the United States, whatever the technology, whether the technology is ALWR, HGTR, LMR, or whatever.

Now, the specimen or the guinea pig that the Department is using in the pressurized water reactor part of the certification program is Combustion Engineering System 80 design, and this is the only advanced LWR design which, first of all exists, has been licensed to operate, and is operating at Palo Verde I, II, and III. It is this design, this concept that we obtained orders from Korea recently in 1987. I signed the contracts, for two units in Korea and they have now announced that they are going to use that technology for their entire future nuclear program.

In addition to addressing the regulatory issue which is certainly on the critical path for a renaissance in this country for nuclear, the Department is looking ahead to a new generation of reactors. The Modular High Temperature Gas Reactor, MHTGR, offers enormous advantages in terms of enhanced operability, simplicity, financial risk abatement, modularity—another form of standardization—and a major reduction of requirements for engineered active safety systems.

Combustion Engineering is pleased to be a part of that program. We endorse the MHTGR fully, and in fact Combustion Engineering and General Atomics have formed a partnership to provide the MHTGR for weapons production purposes.

I note that Mr. Blue is on the next panel so I will not elaborate on the MHTGR and its advantages, and I will finish my oral statement at this time and be happy to answer questions, Mr. Chairman.

[The prepared statement of Dr. Brewer follows:]

STATEMENT SUBMITTED TO
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
OF THE HOUSE OF RESPRESENTATIVES COMMITTEE ON
SCIENCE, SPACE AND TECHNOLOGY

FY 1990 DEPARTMENT OF ENERGY
NUCLEAR RESEARCH AND DEVELOPMENT PROGRAMS

Shelby T. Brewer
President, Nuclear Power Businesses
Combustion Engineering, Inc.
March 1, 1989

Thank you, Madam Chairman, for the opportunity to provide testimony to this Committee as it considers the Department of Energy (DOE) budget for Fiscal Year 1990.

I am Shelby T. Brewer, President, Nuclear Power Businesses, Combustion Engineering, Inc.

Combustion Engineering, Inc., a Fortune 500 company, is a major supplier of systems and services to the electrical power, chemical, petroleum, industrial, and process automation and control sectors. We serve markets here in the U.S. and around the world.

My principal responsibility is the management of the Nuclear Power Businesses (NPB) of Combustion Engineering. Our company designs and manufactures complete nuclear reactor systems, including nuclear fuel. We have manufactured most of the major nuclear components that are currently in use in the United States, including components used by our competitors. We also provide continuing engineering, maintenance, and modernization services to owners of our plants, as well as to the owners of plants supplied by our competitors.

Combustion Engineering designed nuclear reactor systems have attained the highest capacity factor of any vendor in the U.S. in every year but one since 1976. In 1988, four of C-E's reactors were listed among the twenty-five units with highest capacity factors, worldwide. Our St. Lucie-2 unit at Florida Power and Light, which was brought on-line with a construction schedule of only six years, achieved the highest worldwide capacity factor of 100.78% in 1988. The C-E designed Palo Verde-3, operated by Arizona Public Service, recorded the highest worldwide power generation (10,865,800 megawatt-hours) in 1988.

The most advanced, completed, Pressurized Water Reactor (PWR) design in the world today is C-E's System 80. It is not on the drawing board -- as is the case with other advanced LWR concepts -- it is licensed and operating. Three standardized units are operating at Palo Verde.

Based on this de facto leadership, and the performance record of the C-E operating reactor fleet I mentioned above, we were awarded contracts for Korea Units #11 and #12 in 1987 -- the first award, domestic or foreign, to a U.S. vendor in about a decade. The Korea Units #11 and #12 are well underway, and the Korean authorities recently announced that future Korean units will be standardized and based on the C-E design; moreover, they announced the schedule for Units #13 and #14.

I would like to speak to you today about the importance of completing the DOE Advanced Light Water Reactor (ALWR) Design Certification Program in a viable manner that responds to new NRC requirements for certification of standardized designs. The budget level which we are proposing ($3.5 million above the DOE request for FY-90) leaves the total DOE funding for ALWR Design Certification Programs at $5.9 million, a decrease from the current fiscal year.

The ALWR Design Certification Project -- An Institutional Demonstration

Of all the meritorious reactor programs sponsored by the DOE, I regard the ALWR Design Certification Program as the top priority, because it goes to the heart of the institutional barriers to further deployment of nuclear power in the U.S. The program is not a technology development program, and its cost is, therefore, minor compared to other DOE programs. It is not a plant demonstration project aimed at demonstrating a new technology. It is, rather, an institutional demonstration aimed at demonstrating a rationalized, streamlined regulatory licensing/regulatory process -- a process that can better protect human health and safety, as well as restore confidence in nuclear power as a viable economic option, among the utilities and their investors.

Finally, unlike many programs, which have a life of their own, the ALWR Design Certification Program has an end point -- a deliverable at an established point in time, provided that the program is appropriately funded over the next three fiscal years. When completed in 1992, the ALWR Design Certification Program will result in an NRC determination -- in writing -- of the resolution of generic "Unresolved Safety Issues," and a demonstration of a licensing process which allows pre-licensing of standardized designs. Utility executives have repeatedly stated that such steps are necessary as minimum requirements for them to again consider nuclear power as a fiscal risk-worthy energy option in today's political environment. Thus, the ALWR Design Certification Program, or an equivalent which reaches the same result, is a prerequisite for a nuclear renaissance in the U.S.

Furthermore, the Certification Program is necessary to pave the way for NRC licensing of the other advanced reactor technologies by demonstrating the new process for pre-licensing of standardized designs -- a process that is just now being established by NRC. If the Certification Program is not fully completed, DOE and industry will incur considerably greater costs and schedule delays in attempting to license the other advanced reactor designs in the future.

The Need For Design Standardization and Regulatory Reform

As you know, a "nuclear recession" set in during the mid-1970s. This recession persists today although there are some faint signs that the 1990s may see the beginning of a redeployment of nuclear power.

This recession resulted from a complex array of institutional* factors and circumstances:

- A severe electrical capacity demand downturn -- leaving utilities and their suppliers in an overcapacitied situation.
- A high inflation rate, high interest rate economy in the 1970s which, together with protracted regulatory difficulties, multiplied plant capital costs several-fold.
- Capital formation difficulties -- a transition in the 1970s from an era of utility capital surpluses (and rate reductions) to an era of capital deficits (and rate increases).
- Erosion of the national political base (given birth generally in the 1950s) for nuclear power in the 1970s -- with the dissolution of the JCAE, government programatic failures in waste management, government policy instability regarding reprocessing and breeder development, together with an increasingly virulent anti-nuclear, anti-technology movement.
- Lack of nuclear plant standardization -- a "megawatt" race in the 1960s and 1970s, leading to a heterogeneous array of individualized plants -- custom-designed and therefore custom-regulated.
- Regulatory uncertainties -- an ad-hoc, incremental, design-and-regulate-as-you-go process, strangling an industry which was struggling toward maturity.

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* I use the word "institutional" here as a summary word to capture political, regulatory, and economic factors.

Several of these circumstances have abated -- for example, in the 1980s, economic growth has restored electrical demand growth. The inflationary, high interest rate economy of the 1970s has been corrected. And the political dialogue on nuclear power is marginally more reasoned -- nuclear power is regarded just a bit less as "sick and dependent." The glass is half full, not half-empty.

If I could establish a national nuclear agenda for the next several years, it would address the last two factors on the list above -- standardization and regulatory reform. Standardization of both the product and the associated licensing/regulatory process are prerequisites for further consideration of nuclear power as an option for new capacity. Utilities and their investors will simply not absorb the financial risks, as they once did, of an uncertain and often capricious regulatory process, nor will they accept one-of-a-kind products, much less first-of-a-kind products. The threshold for marketplace acceptance is the availability of pre-licensed standardized designs (in detail), together with some form of one-step licensing (e.g., combined construction and operating license). These conditions prevail whether the plant is a LWR, an ALWR, a "passive" LWR, an MHTGR, or an LMR.

These views were expressed to Congress last year by James O'Connor, Chairman and CEO of the Commonwealth Edison Company, and William Lee, Chairman and CEO of Duke Power Company. These gentlemen represent the largest and most successful nuclear utilities in the nation. Their advice should not be disregarded.

During my service in the Reagan Administration, Standardization and Regulatory Reform legislation was proposed to Congress (1983). That legislation, and many variants of it, have been extensively debated in the several House and Senate Committees with oversight responsibilities.

The Nuclear Regulatory Commission (NRC), in the meantime, has taken several steps toward rationalizing the process along the lines proposed in the Reagan bill. For example, a Backfit Rule has been enacted. An NRC regulation (10CFR52) on standardization -- review and certification of standardized designs -- is in preparation. These NRC initiatives may or may not supplant the desirability of legislated regulatory reform -- that remains to be seen. A major question is whether or not the NRC can and will fashion a satisfactory combined construction and operating license format, without legislation.

In any event, DOE's ALWR Standardized Design Certification project complements these initiatives, legislative or administrative, to reform the regulatory process. I will say it again: the Certification project is an institutional demonstration, not a technological development/demonstration. Using existing commercial designs, produced at Combustion Engineering's and General Electric's expense, it provides a vehicle for resolving generic "unresolved safety issues" industry-wide, independent of reactor concept -- independent of choice of coolant, neutron physics, fuel cycle class, and specific design variants. Further, the Certification project will demonstrate the viability of a process allowing pre-licensing of standardized designs, of whatever technology.

Advanced Reactor Programs

Before discussing DOE's advanced reactor development programs, it is useful to review a bit of history.

Development of advanced nuclear systems, beyond the horizon of the private sector, is a responsibility vested in the Federal Government by the Atomic Energy Act of 1954, as amended, along with several crucial operational responsibilities such as safety regulation, nuclear waste disposition, and uranium enrichment. The central path of national advanced reactor development until 1983 was the U.S. Liquid Metal Cooled Fast Breeder Reactor (LMFBR) program. This program was defeated in Congress in 1983 with the demise of the Clinch River Breeder Reactor (CRBR) project.

With the pacing down of the breeder program after 1983, the DOE and industry considered a broad spectrum of other developmental programs and in time these were reduced to: MHTGR, "passive" LWR, and LMR. In all of these cases, the attributes sought were enhanced operability, financial risk abatement, modularity, and a reduction of requirements for engineered, active safety systems, as opposed to fuel resource conservation, the central driver in the LMFBR program.

Development of these options is in the national interest, and is endorsed by the industry and the nuclear utilities. Combustion Engineering is involved in the development of the MHTGR and is working with British authorities in responding to the DOE RFP on the "passive" LWR.

Modular High Temperature Gas Reactor (MHTGR)

The MHTGR offers enormous conceptual advantages:

- A benign coolant -- helium -- which does not become activated, making maintenance of equipment significantly easier.
- A large thermal "sink" -- graphite -- which results in long time constants during off-normal events, and thus allowing hours rather than minutes for operator action.
- A higher thermal efficiency than the current generation of reactors.
- Modularity -- much of the erection can be accomplished in a central manufacturing facility, allowing better quality control than field erection.
- Smaller capacity -- modules of 135 MWe permits tailoring capacity additions more closely to demand requirements.
- One phase coolant -- heterogeneities, liquid level concerns are eliminated.
- Fission product retention -- the TRISO coated fuel particles remain intact under normal operating and accident conditions and are therefore the primary barrier for retaining fission products.
- Simplicity, operability -- the simplicity and operability features, together with modularity, make the MHTGR an ideal export product to developing countries with little technical infrastructure.

Combustion Engineering, General Atomics, Stone and Webster, and Burns and Roe have teamed to offer the DOE Defense Production organization an MHTGR as a New Production Reactor (NPR). The recent selection by DOE of the MHTGR, as one of two technologies to be used in the NPR projects, is heartening.

Safe Integral Reactor (SIR)

In response to the Department of Energy's Simplified Passive Advanced Light Water Reactor Plant Program, Combustion Engineering, as prime contractor, is proposing a design termed the Safe Integral Reactor (SIR), rated at 320 MWe per module. Our subcontractors are Rolls-Royce and Associates and the Atomic Energy Authority in the U.K., and Stone and Webster in the U.S. The U.K. Atomic Energy Authority has expressed interest in hosting construction of SIR Unit No. 1 at its Winfrith, Dorset site.

Summary

To summarize, standardization and regulatory reform are prerequisites to further deployment of nuclear power in the U.S. Legislation addressing standardization and regulatory reform is the top priority of the nuclear industry. While this legislation is being considered by Congress, the NRC is taking steps to rationalize and improve the licensing and regulatory processes, including the preparation of a regulation governing standardization (10CFR52).

DOE's Standardized Design Certification project complements these efforts by providing a demonstration of the viability of a process which allows pre-licensing of standardized designs. This project is an institutional, rather than a technological, demonstration, and its cost is therefore minor compared to other DOE programs. Because this project goes to the heart of institutional barriers to further deployment of nuclear power, is a minor cost item, and enjoys 50% cost-sharing by its contractors, it should, in my opinion, receive top priority in your deliberations.

The budget level which we are proposing ($3.5 million above the DOE request for FY-90) leaves the total DOE funding at $5.9 million, a decrease from the current fiscal year.

The DOE is considering an array of advanced reactor technology development programs. Among these, the Modular High Temperature Gas Reactor (MHTGR) deserves particular emphasis as a candidate for the next generation of nuclear plants. Its features enhanced operability, financial risk abatement, modularity, and a reduction of requirements for engineered, active safety systems.

Because of the world's vast experience in light water cooled reactor technology, a modular LWR approach should be pursued. The DOE's Simplified Passive Advanced LWR Program, now in a formative stage, will address this concept.

Mr. STALLINGS. Thank you, Dr. Brewer.

The third member of the panel is Dr. D. Clark Gibbs, the Division Director for Atomics International of Rockwell International Corporation. Dr. Gibbs is also a familiar face from his Clinch River days and we welcome him before the Subcommittee and look forward to his testimony.

Dr. Gibbs.

STATEMENT OF DR. D. CLARK GIBBS, ACTING GENERAL MANAGER, ENERGY TECHNOLOGY ENGINEERING CENTER, ROCKWELL INTERNATIONAL CORP.

Dr. GIBBS. Thank you, Mr. Chairman. I'm also the Acting General Manager for the Energy Technology Engineering Center which is operated by Rockwell, and it is in that capacity that I'm here before you today. I will not attempt to address any other interest that Rockwell has with respect to this subject before this Committee.

The Energy Technology Engineering Center which I will refer to in the future as ETEC, although it had its origins with Liquid Metal Reactors, has evolved substantially over the past 10 years to be a provider of technology and demonstration test support for all energy technologies, not just Liquid Metal Reactors. In fact, we support activities in solar; geothermal; we have worked in ocean thermal energy conversion; we have worked on several conservation programs; and we have provided support for Light Water Reactors through the years.

In fact, the degree of diversification of our activity is aptly illustrated by the fact that in FY '89, some 64 percent of our funding came from sources other than DOE-NE. Only 36 percent was derived from DOE-NE and was used to operate the Sodium Components Test Installation, or SCTI, which is the facility that is used to test sodium heated steam generators.

Before I leave that subject, one thing I should mention as an example. We are currently constructing a facility for testing steam valves, which when complete will be the largest in the world. And in fact we will have a capacity for testing steam valves at steam flow rates approaching that of a modern Light Water Reactor.

Despite the fact that we have diversified substantially through the years, our core still is embedded in the Liquid Metal Reactor technology area as the operator of the SCTI. That core furnishes us with the ability to deal with customers that come and go. The 64 percent of our business that comes from sources other than NE are all intermittent customers. The NE's funded activity provides us with that core of operators and that core of engineers which enables us to assume these intermittent activities that come from other customers.

As you have indicated, Madam Chairman, in your opening remarks, the budget that has been provided by DOE-NE is a shutdown budget for ETEC. And the reason for that is that it will not support the continuation of the core, and when the core is removed, the intermittent programs that the core supports when they are complete will ultimately languish and the activity at ETEC will ultimately languish along with it.

Now, despite the fact that most of our programs now come from sources other than Liquid Metal Reactors, it's the Liquid Metal Reactor facilities at ETEC that remain the crown jewels of ETEC. Their replacement value today would probably represent a cost of over $500 million.

Furthermore, regardless what Liquid Metal Reactor ultimately evolves from the current activity and is ultimately deployed, it almost certainly will have pipes, pumps, valves, instrumentation and so forth, all of which will require testing.

Of the test facilities that are ETEC, one of the interesting things about test facilities is that even though the test articles that they are testing may ultimately change with time, the test facilities do not. They do not become obsolete. And if those facilities are no longer available when this technology ultimately is deployed, they will have to be reconstructed in some fashion, at a very significant cost.

Now, the third point I think that I need to make is that we have, as a result of our past and present operations, incurred commitments with others who are dependent upon our continued survival at ETEC. One example of this is that by using the waste heat from one of the sodium heaters at ETEC, we are providing the energy necessary to power a thermodynamic cycle that was invented by a Dr. Kalina that uses an ammonia and water mixture, and which promises theoretically at least to yield thermodynamic efficiencies 10 percent higher than those that are typically available from water rankine cycles. He needs a demonstration of that technology and he has already paid for the design that he intends to install at ETEC and he has already begun to fabricate some of his equipment.

He has financed this through venture capital from both foreign sources and the United States, as well as some $5.0 million from the State of California. If ETEC doesn't operate beyond FY '89, the financial consequences on Dr. Kalina, of course, are going to be negative.

Another commitment that has been made has been the commitment with the Japan Atomic Power Company to test the double-walled steam generators at ETEC during FY '91 and '92. That commitment involves a substantial contribution from the Japan Atomic Power Company. The Japan Atomic Power Company is also, of course, expecting that the DOE will come forth with their contribution to continue that testing.

If that testing does not go forward, other cooperative activities which are currently contemplated, that involve the Japan Atomic Power Company, most notably the IFR, also potentially are at risk.

So our conclusion is that this course of action which the DOE is on which would in all probability result in the shutdown of ETEC is probably not a very good idea for several very good reasons.

I have summarized now for you what is already contained in my written testimony. Thank you very much.

[The prepared statement of Dr. Gibbs follows:]

STATEMENT OF

D. CLARK GIBBS
VICE PRESIDENT AND GENERAL MANAGER (ACTING)
ENERGY TECHNOLOGY ENGINEERING CENTER
ROCKETDYNE DIVISION, ROCKWELL INTERNATIONAL CORPORATION

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

OF THE

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

Madam Chairman and members of the subcommittee, I am pleased and honored to have the opportunity to meet with you today. I am here today to represent the interests of Rockwell International as the operator of the Energy Technology Engineering Center (ETEC) which is owned by the Department of Energy (DOE). I will not attempt to represent Rockwell's other interests that are applicable to the subject of this hearing.

The DOE intends to reduce the funding for ETEC that is derived from DOE-NE to $7.1M in FY90. This is about $7M less than is required from that source and will, in our opinion, most likely result in the closure of ETEC and the loss of that valuable resource to the nation. My purpose for being here today is to tell you why we think that is a very bad idea, and why our funding requirements are as they are.

ETEC has evolved considerably over the past ten years since the days when it was exclusively a testing center for liquid metal systems and components. It now is a development center that supports or has recently supported many energy technologies including solar, geothermal, fusion, conservation, advanced coal, ocean thermal energy conversion, and light water reactors. Despite the fact that its considerable facilities have a replacement value in excess of $500 Million, it operates on a relatively modest budget of around $30M annually. The degree to which it has diversified is illustrated by its funding sources in FY89. ETEC currently derives 36% of its financial support from DOE-NE, 16% from DOE sources other than NE and 48% from non-DOE sources. This is a far cry from five years ago when 84% of ETEC's funding came from DOE-NE. The DOE-NE funding profile for ETEC for the past 10 years is included herewith as Figure 1.

During its recent history some new facilities have been constructed that are noteworthy. A steam system test facility, currently under construction, will have the capability to test to steam flow rates as high as 9 million pounds per hour - about 10 times greater than any comparable test facility and nearly comparable to the steam flow in a large nuclear plant operating at full power. This facility is being constructed at no cost to DOE-NE. A seismic fragility test system has been installed to test piping systems to destruction under extraordinary seismic conditions. No comparable system exists worldwide. A new test fixture for testing seismic isolators is being installed. A space advanced components engineering facility is partially complete that simulates the space environment and has been provided with a 10,000 KVa power supply and a committed heat rejection system.

Two challenges facing the DOE now that have received much recent attention are the environmental restoration of existing defense sites and the modernization of the production facilities including the design and construction of two new production reactors. On the former, ETEC has accumulated over 20 years of experience in the technique and technology of decontamination and decommissioning. This capability represents a unique resource available to the government for deployment to the effected sites. The experience accumulated by this group should be capable of ensuring that future remediation efforts enjoy the benefit of past lessons learned. On the latter, ETEC's history as a development and test site for new reactor designs and its wealth of installed facilities is ideally suited to provide support at a modest cost for both the HWR and the HTGR.

ETEC's new facilities reflect the dynamics of the changing environment in which ETEC has been successfully operating over the past several years. But despite the added breadth of capability they afford, the crown jewels at ETEC continue to be the large sodium testing facilities, the Sodium Components Test Installation (SCTI) primarily intended for testing steam generators, and the Sodium Pump Test Facility (SPTF). These two facilities are by far the largest such facilities in the world. Furthermore, the SCTI provides the core of operators and engineers around which we can assist the many other interests that call upon us intermittently. Since most of the users of ETEC call for facilities or capability unrelated to the SCTI, only DOE-NE can be relied upon to provide the support necessary to maintain the core in operation. If the core is removed, ETEC will soon thereafter become nonviable when its current work assignments with transient customers are completed.

Our funding from NE in FY89 is $11.4M following five years of precipitous decline from the FY84 level of $31.8M. In FY89 we used $1.5M for SCTI support that had been received from another user of the SCTI that offset DOE-NE costs. Because of the payment schedule of that user, no funds will be received for SCTI operations in FY90, transferring this burden to DOE. In addition, environmental requirements, one of which is a recent change, require that a small amount of additional investment, on the order of 0.6M be made in the SCTI in FY90. Providing another 0.6M for escalation and adding these requirements to the FY89 DOE-NE funding, we arrive at $14.1M as our requirement for FY90. This level of support will be tight, but adequate to permit continued operation of the SCTI through FY90.

Interest in sodium cooled reactors continues to be relatively modest since the Clinch River Breeder Reactor Plant Project was cancelled in 1983. That project enjoyed consensus support from a large fraction of the advocates of the promotion of the use of nuclear power in this country. Its cancellation was a huge disappointment to those advocates, and the effects of that disappointment continue to be experienced today. Nonetheless the basic merits of liquid metal reactor technology have not changed and renewal of substantial support, development, and deployment is as inevitable as day following night.

Liquid metal cooled fast spectrum reactors have long been recognized as offering superior flexibility in deployment options compared with thermal spectrum reactors. First, their high power density causes them to be ideal for space and marine applications. Second, their excellent neutron economy makes then about twice as effective as thermal reactors when operating in the production mode. Third, the chemical and physical properties of the coolant provide the means for achieving an excellent prospect for economy in a well designed plant. Fourth, the high energy spectrum can be used to burn waste actinides, reducing by factors of 1000 or more the long term hazard of disposed high level radioactive waste. Finally, the fast spectrum reactor is the only concept that can be deployed effectively as a breeder.

In addition, by comparison to thermal spectrum reactors, fast reactors are less susceptible to plant aging, offer greater prospects for capitalizing on economics of scale, can be operated for longer periods between refueling, should require substantially less maintenance, and should be far simpler to operate than thermal reactors. They will operate at higher thermal efficiencies reducing environmental impact by requiring less cooling water, and should be easier to construct. Their operation results in much lower radiation exposures to plant workers and should lead to reduced turnover among maintenance personnel. They have won acceptance world wide as the reactor system of choice for the future and have attracted significant development activity in at least ten nations. That activity has solved many of the problems that surfaced in the early period of development of the concept which now spans 38 years. The U. S. alone has over $16 billion of present worth investment in sodium cooled reactors.

While design, construction and deployment of nuclear plants continues abroad, new activity has been temporarily interrupted in the United States. Although the causes of the current hiatus are fairly well understood, one cannot predict with certainty when the demand for nuclear energy in the United States will re-emerge.Recent factors, most notably the media attention and public awareness given to the greenhouse effect, as well as the relatively high rate of load growth among electric utility companies tend to improve the prospects for deployment earlier than might have been expected three years ago after the Chernobel accident. In addition, 1988 was the first year that domestic nuclear plants showed a significant improvement in performance as measured by capacity factor. Also, recent public opinion polls taken by the Council for Energy Awareness suggest that the public is now perceiving an increasing role for nuclear power as the means for electric power generation in the future. One thing that is certain is once the log jam is broken and the first new plant is started, it will be followed by a large number of other plants in short order. The changing conditions which allow one electric utility company to start a plant will apply to them all in much the same way. As soon as this happens, interest in sodium cooled reactors will immediately recur, fueled possibly by price speculation in yellowcake, by general acknowledgement of the basic limitations imposed by domestic uranium availability, or by a desire to capitalize on one of the other performance advantages offered by these reactors discussed briefly above.

If the reasonableness of this scenario is accepted, what path is indicated today? If an LMR design is initiated in the future, it will very likely contain pumps, heat exchangers, instrumentation, valves, and other components similar to those that have been and are being tested at ETEC. It is likely, however, that many of these components will be very different from today's designs and will therefore require testing.

Beyond the need to make occasional minor upgrades, test facilities of the type installed at ETEC are unlikely to become obsolete. Moreover, since the ETEC facilities are not driven by a reactor, change in test article configuration and interface with the facility can be readily accommodated. Failures of the test article during test have no untoward nuclear consequences. Changeout, repair, and reinstallation can be achieved with relative ease since the facilities were primarily designed for testing rather than for design basis nuclear accidents. This logic is a strong argument for the preservation and maintenance of the facilities at ETEC.

If the wisdom of the preservation of the LMR test facilities at ETEC is accepted, how might they be effectively deployed today? An obvious area for current investigation is steam generator testing. Generic issues surrounding steam generator design have been outstanding since the early days of the Fermi reactor and require resolution. Despite the fact that the steam generator is widely acknowledged to be the most difficult design problem with LMRs, there has yet to be any endurance testing of steam generators of a modern U.S. design. The issue of long term steam generator performance is exactly the problem that ETEC had intended to resolve during FY90 with endurance testing of a modern steam generator design at the SCTI. The lessons learned from the endurance testing conducted at ETEC in FY90 will be applicable to sodium heated steam generators of any design.

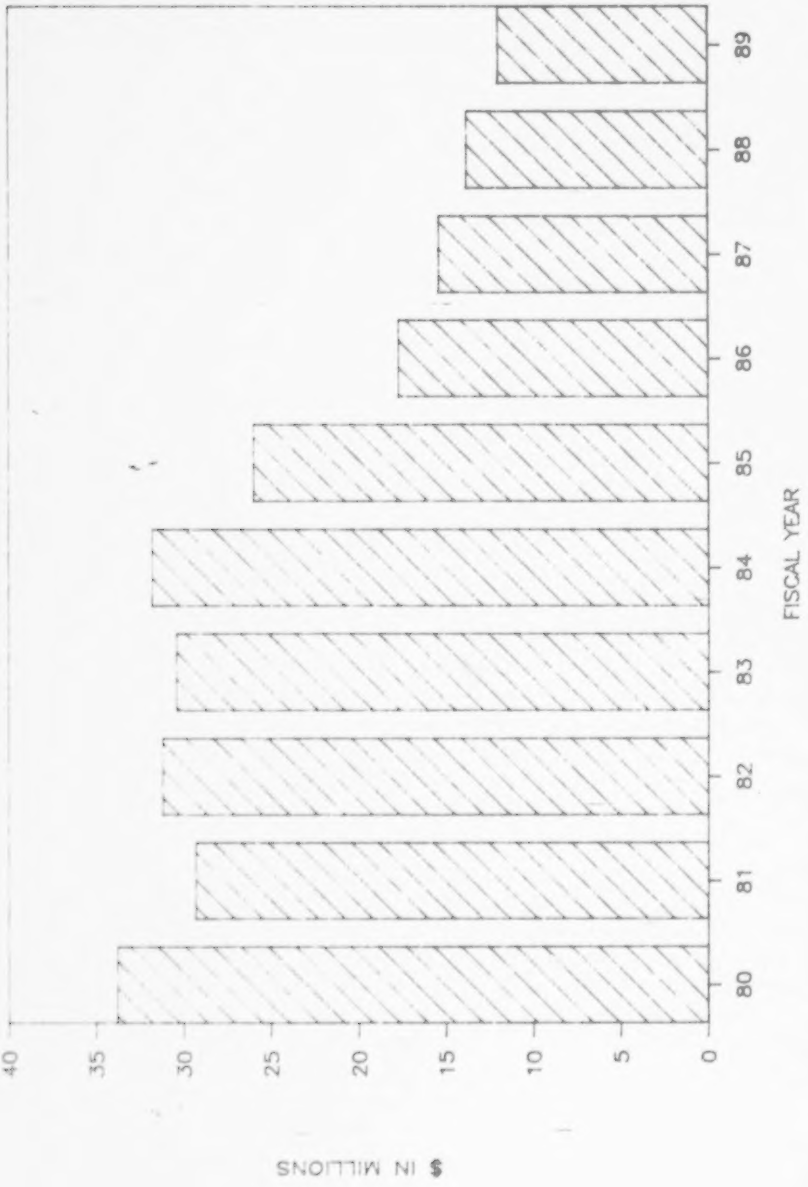
Endurance testing of steam generators on the SCTI has only recently become practical with the completion last summer of the $15M Power Pak - a cogeneration unit whose generated electric power supplies revenues that offset the fuel and electric costs of operating SCTI. Another recent SCTI improvement is a $2.5M preheater, now under construction, which will improve the thermodynamic efficiency of its associated heater by about 10%. If SCTI is decommissioned now, neither of these recent investments will yield any return and the outstanding Power Pak debt will require settlement.

A steam generator on which a considerable amount of favorable data exists is that which is installed on the EBR-II reactor. A modern design embodying the main feature of the EBR-II design is planned for testing in the SCTI in 1991. This test will last approximately two years and has attracted the financial participation of the Japan Atomic Power Company (JAPC) which will partially offset DOE's costs. JAPC has also expressed an intent and willingness to bear the full cost of utilizing ETEC's Sodium Component Test Loop and its large Sodium Pump Test Facility for subscale tests and full size tests of the sodium pumps it intends for deployment in its Demonstration Fast Breeder Reactor. Another user of the SCTI is Exergy, Inc., which plans to use waste heat to demonstrate a novel thermodynamic cycle using an ammonia-water working fluid. If this demonstration is successful, its promotor, Dr. Alex Kalina, intends to market his product further as a means of generating electricity at significantly higher efficiencies, compared to today's boiler systems. Exergy has attracted both domestic and foreign venture capital to support the planned testing. In addition, the California Energy Commission has loaned Exergy about $5 Million, repayable out of a share of the operating cost reduction attributable to the Kalina cycle to be derived from revenues derived from operation of the plant installed on ETEC's SCTI. Exergy has already made significant financial commitments in design and equipment procurement for its intended demonstration at ETEC. Failure to provide adequate financial support for ETEC will inevitably lead to adverse consequences for Exergy, the State of California, and JAPC and will certainly complicate or abrogate DOE's planned efforts to expand its cooperation with JAPC on the Integral Fast Reactor (IFR) studies.

In DOE's budget request for FY90 tnat supports their proposed $7.1M level of funding for ETEC in FY90, DOE-NE has expressed the intent that additional cost-sharing be obtained from others to match their financial participation. As has been shown in this testimony, ETEC already derives the majority of its support from sources other than DOE-NE. But most of these alternative users of ETEC are interested in facilities or services that do not involve the SCTI, the core of ETEC's operation. Given time, it may be possible to identify SCTI users whose participation at ETEC could gradually reduce DOE-NE's financial participation below even current levels. The British, for example, have recently expressed interest in possible use of the SCTI to test steam generators of their design. But there is not enough time between now and the start of FY90 to achieve such an ambitious goal. It is our conclusion therefore that if the $7.1M DOE-NE funding level is implemented, the result will be the untimely and unfortunate loss of an important national resource which will require major new investments to be made to support near term projects as well as later, when the inevitable rebirth of nuclear occurs.

DOE–NE FUNDING PROFILE

1980 – 1989



Mrs. **Lloyd**. Thank you very much, Clark. It's good to see you back with us today as well as our other witnesses. It's always a pleasure to be with you.

PANEL 2 DISCUSSION

Mrs. **Lloyd**. Dr. Wolfe, is G.E. the only owner of the advanced BWR design?

Dr. **Wolfe**. We have developed the Advanced Boiling Water Reactor—let me go back. In 1979 we got all of the Boiling Water Reactor people, our licensees in effect from around the world—Sweden, Italy, Japan—and formed a team to develop the design of a reactor based on the best experience.

That design ultimately became the Advanced Boiling Water Reactor which is being built in Japan by, as I said in my testimony, G.E., Hitachi, and Toshiba. We will all own the rights to that design. It's a tremendous advantage to the United States, I might say. There has been over $250 million spent in development work on that reactor, test proving it; not a penny from the Department of Energy, I might say. And we, the United States—and I might add, General Electric in particular—has access and the rights to use that technology, as does Hitachi and Toshiba.

Mrs. **Lloyd**. Would profits of this sale go to Japanese firms, or how would this be handled?

Dr. **Wolfe**. No. Let me say on the ABWR, the split in Japan—we'll have the steam supply system and the fuel and the turbine, that's about a third of the total cost—so we will have a third, Hitachi will have a third, and Toshiba a third.

When we sell the plant in the United States, it will be our plant to sell and we would make arrangements to sell it here. My guess is the first plant we would get help from Toshiba and Hitachi perhaps in some of the components, where they might not be available here in the United States. But fundamentally it's our plant with no commitments to anyone else.

In a similar way in the later plants in Japan, Hitachi and Toshiba would have the rights. I might say we've just had an outstanding relationship in Japan and we are still working with our Japanese colleagues on all of the previous plants we supplied there.

Mrs. **Lloyd**. What sort of components will they furnish for you?

Dr. **Wolfe**. Hitachi and Toshiba?

Mrs. **Lloyd**. Yes.

Dr. **Wolfe**. Well, for example, we will probably, although it's in our scope of supply, buy a pressure vessel over there from Hitachi and Toshiba since it's unlikely we can get the kind of pressure vessel that we need here and the cost of shipping it over would be prohibitive.

Some of the piping we would fabricate over there. We might get it here, send it over, and get it modified.

Mrs. **Lloyd**. So some of the work is very labor-intensive?

Dr. **Wolfe**. Yes. The fuel we develop here, and we haven't made a final decision whether we will make the fuel in the factory which we own over in Japan with Hitachi and Toshiba, or make it here in our factory and ship it over.

Mrs. **Lloyd**. Does G.E. envision any kind of turnkey contracts for the Advanced Boiling Water Reactor?

Dr. **Wolfe**. I think that's an interesting question. In Japan, that program for Tokyo Electric Power is a turnkey program with the three of us—Toshiba, G.E. and Hitachi—sharing it, and that's an impossibility in this country right now for reasons that Mr. Brewer just mentioned.

In Japan you can get a license for a plant. We will be licensed in 1991 in Japan. The schedule is to have the plant in operation in 1996 and, based on our experience in Japan and the licensing methodology there, it's going to be in operation in 1996, and the cost therefore can be kept under control.

In this country, as you know, plants which were supposed to cost a half a billion dollars when they were ordered——

Mrs. **Lloyd**. This is our problem because of the long lead time to put the plant into production.

Dr. **Wolfe**. Well, it's the licensing and the changing of licensing requirements as the plant operates, so that when you start a plant here, you're never quite sure what it's going to end up looking like when you're done.

Mrs. **Lloyd**. As Mr. Morrison and I were talking about, the one-step licensing would go a long ways to alleviate many of our problems.

Dr. **Wolfe**. Absolutely.

Mrs. **Lloyd**. Would you envision—I'm not holding you to this—but would you envision that with one-step licensing we would be a little bit closer to another commercial order domestic facility?

Dr. **Wolfe**. Absolutely. I see no reason why we in this country couldn't take the ABWR design, which as Mr. Stello indicated, is going to be licensed in this country in 1991, and if the need were there, build it here in the four to five years that we build them in Japan.

Mrs. **Lloyd**. We hope that can become a reality before too much longer.

Dr. **Wolfe**. We do, too.

Mrs. **Lloyd**. Clark, the Administration suggests, as you heard from their testimony today, that you obtain greater contributions from other sources to offset the $7.0 million that they have cut out of your budget for ETEC.

Do you have any prospects of finding this type of funding?

Dr. **Gibbs**. As I stated in my summary remarks, we already derive a substantial amount of our funding from other sources. But that funding does not support the SCTI. We have a little bit right now that supports the SCTI, some of which will go away next year, that will have to be restored by DOE.

But by and large, the other users are seeking for us to do things other than run the SCTI. They are looking for us to work with solar programs, conservation programs, whatever. I suspect that, given time, it may be possible to find other users. The British have indicated an interest in testing steam generators of their design in ETEC and that could materialize——

Mrs. **Lloyd**. You think perhaps there can be additional sources, outside sources of funding? Do you think there is a possibility of outside sources of funding?

Dr. GIBBS. I think there is, given time, but not in the time we have for FY '90. I think the FY '90 budget is very clearly a shutdown budget for ETEC.

Mrs. LLOYD. If the facility should, and we hope it doesn't, close down in '90, is it possible to restart the facility at a later date?

Dr. GIBBS. Well, it's necessary to be careful because there are two possible courses of action. One course of action would be to put the facility in lay-up, where you take specific precautions to ensure that—remember that this is a facility that's containing sodium, so when you lay up that facility and intend to reuse it, you must do so with great care. And we're currently doing that now with facilities such as the sodium pump test facility and the sodium components test loop. Those facilities right now are in lay-up and not being used, but they are being preserved by us.

Now, presumably, we could do the same thing with the SCTI, but if we were to do so, we could not honor the commitments that we have with Kalina and with JAPC for 1991 because if we put the facility in lay-up, we will lose the operating and engineering talent that's necessary to restart it in 1991. The only motive for putting it in lay-up would be to save money. To save money, we would have to transfer those people out and they would be lost.

Now, the second course of action if you don't go the lay-up route is to go the decommissioning route, and I believe it's the decommissioning route that is what is intended. And in that case, beginning in '91, we would actually start to dismantle the facilities. Now, that would represent, as I indicated, a loss of over $500 million in replacement value for these facilities.

Mrs. LLOYD. Let me ask you this. Is there any level of funding below $7.0 million that would keep the facility open?

Dr. GIBBS. A question like that is always a difficult one. The context of my answer would have to be that we have been on a declining budget profile from DOE since 1984, a precipitous decline. In '84 we received about $34 million from DOE, or $32 million, in that range, and this past year our DOE-NE budget was just slightly over $11 million.

Now, we have achieved that by tightening the belt and cutting as many corners as we can cut while still keeping our operations at the requisite required level of quality and safety. I don't believe there is any fat in our $14 million estimate. The written testimony gives you some indication of how we arrived at the $14 million that we would require on the basis of what we used this year in '89.

Mrs. LLOYD. Well, we will be following your comments and your complete written testimony. We will also be submitting some questions in writing for you that we would like you to respond to for the record of this hearing.

Dr. GIBBS. I would be delighted to, Madam Chairman. Thank you very much.

Mrs. LLOYD. Dr. Brewer, as you know, you've been Assistant Secretary for Nuclear Energy, you've been our lead witness in previous years, and certainly we have enjoyed working with you over the years. And now you are on the other side of the table as an officer of Combustion Engineering.

I really just couldn't wait to ask this. The consistency in the program funding request for the Department of Energy is really a problem for the private sector to maintain the programs that you have agreed on. Isn't this pretty frustrating for you?

Dr. **Brewer**. Yes, Madam Chairman, it is a problem. I don't know that it is any more of a problem now than when I was Assistant Secretary. The record is replete with Uncle Sam starting something, and then you get down the pike and then have a better idea and start something else, not completing things that they start.

It seems to me we wasted billions of dollars in our start and stop approach, not only in energy programs, but defense programs, conservation programs. We don't have a good record as being a reliable partner.

Dr. **Brewer**. We wasted 20 years—not wasted—but the breeder program which crashed in the '84, '85 time frame after the defeat of Clinch River.

Mrs. **Lloyd**. We remember it well.

Dr. **Brewer**. Yes, very well. I hate to bring that subject up.

Mrs. **Lloyd**. I really hate for you to bring it up, too.

I am concerned that the NPR project will not be properly coordinated with the civilian program, the NPR/MHTGR program.

Do you have a concern in this area? Have you noticed any failures in communication between the civilian and the military programs?

Dr. **Brewer**. First of all, Madam Chairman, at this point in time there is no NPR/MHTGR program. It is one which we hope will get initiated in FY '90. There are some concerns and issues about redundancy between the two programs. Are the two programs going to be doing much the same thing?

So I know there is a lot of effort in the Department to identify areas that one program or the other should do and not duplicate certain technical activities.

Mrs. **Lloyd**. I think Mr. Stallings has to leave pretty soon. He has another meeting. I want to apologize to everybody. We have about four meetings going on at the same time. This is a bad day on Capitol Hill. And Mr. Stallings has to go somewhere, so I'm going to yield to Mr. Stallings.

Mr. **Stallings**. Thank you, Madam Chairman.

Mrs. **Lloyd**. And I appreciate you chairing the hearing this afternoon.

Mr. **Stallings**. I was glad to. This has been very interesting for me. I have some very strong concerns in these areas.

Let me address this first question to both Dr. Wolfe and Dr. Brewer. Would each of you identify any deficiencies that exist in DOE's current R&D budget proposals and then recommend any changes that need to be made, especially with regards to the Department's funding priorities.

Dr. **Brewer**. We are recommending, Mr. Stallings, on the plant design certification program—this is the one that I spoke of in my introduction—a budget of $5.9 million versus the $2.4 million that the Department requested, and identify the justification and rationale for that project in my introduction and it is also in my written statement, that it's not a technology development program and therefore it's not a plant demonstration. What it demonstrates is a new licensing format which goes right to the heart of the major inhibitor of further deployment of nuclear in this country. For that reason, I think that is the top priority of the Department.

Mr. **Stallings**. Dr. Wolfe?

Dr. **Wolfe**. Yes. I think that's an excellent question. I wonder if you would let me answer it first very generally and say that in my view, the Department does not take firm programmatic objectives and see them through on a consistent basis to the end.

If we want a breeder program, we should have a time scale for the breeder program. That's what we gave to the Department of Energy after a five-year, multi-industry program in which we had three competitions and finally ended up in January of this year with a final program with time schedules, with R&D programs, with results. We had a program and it was a funded program that was reviewed in detail by the Department of Energy.

Now we find that, as I told you, that in our case the program was reduced from $16 million to $4.0 million. In the case of Argonne, at least the part that I know, it was reduced from something like $20 million to $6.0 million. Now, clearly, that is going to have a big effect on whether we accomplish anything.

To Mrs. Lloyd's point, the net effect is that we are going to spend money and, in my opinion, we're going to just spin our wheels. And we are going to end up, again to put it very candidly in my view, we're going to end up seeing the Japanese and our European friends take the leadership from us and we're going to be sitting here wondering why, in the future, we have reached that position.

I've given you the LMR. In the case of the small reactors, the Light Water Reactors that we're working on and Westinghouse is working on, that program, we have just finished a major phase. It looks extremely well. The Department of Energy has asked us for a program which will have major cost sharings by us and our overseas partners to develop that simplified, safe and passive system.

In order to do that, we're going to need consistent funding from the Department of Energy. And I think to what all of you have said here, we have some questions whether we're going to get that consistent funding. So if we don't, then we're not going to meet the objectives.

In summary what I'm saying, on all of those programs the objectives ought to be laid out carefully, the time scale ought to be laid out carefully. What we have to do ought to be laid out, and we ought to see them through until we find out that the program is a failure. We're not doing that.

Mr. **Stallings**. As a followup, Dr. Wolfe, what kind of foreign policy implications do you see in the Advanced Liquid Metal Reactor program?

Dr. **Wolfe**. I think the Advanced Liquid Metal program—let me say the whole nuclear program started out after President Eisenhower's Atoms for Peace Program, not to develop nuclear power in this country, but to take the leadership of nuclear technology worldwide for nonproliferation purposes.

It was an outstanding success and it turned out we needed nuclear power more than we thought at the time of Eisenhower's speech. So we did both.

But we still have the problem of seeing that as plutonium is used worldwide, that it's used in a way which minimizes the possibility of nuclear weapons getting into hands that they shouldn't be into.

The nice thing about the LMR program and our PRISM program is it provides a fuel cycle that in my view is very sound in terms of proliferation resistance. And the danger that I see in our nonproliferation policy, that if we don't take the leadership which we now have the opportunity to do in the LMR program, that plutonium is going to be used abroad, that the breeder is going to be developed abroad, and that we will lose the influence and the leadership to put that plutonium usage in a form that will be acceptable to us from our foreign policy, our nonproliferation objectives.

I think we have a tremendous opportunity right now and we're going to lose it, in my view, if we don't go ahead.

Mr. **Stallings**. Thank you, Dr. Wolfe and Dr. Brewer.

Mrs. **Lloyd**. Thank you very much. All three of you gentlemen have provided outstanding testimony to the subcommittee and have provided leadership in the field of energy for our nation for a great many years, and we are very grateful for your contribution to the energy program of our country.

Mr. Schiff?

Mr. **Schiff**. I have no questions. I want to thank the panel.

Mrs. **Lloyd**. Mr. Morrison?

Mr. **Morrison**. No, thank you.

Mrs. **Lloyd**. Thank you, gentlemen, for being with us.

Our third panel includes Dr. Linden Blue who is Vice Chairman of the Board, GA Technologies; and Mr. David Hoffman, Vice President, Nuclear Operations, Consumers Power Company, representing the Gas Cooled Reactors Association.

Thank you for being with us. It is also delightful to have you with us today, and we are excited to hear all that is going on in the Modular HGTR field.

Dr. Blue, you may proceed.

PANEL 3

STATEMENT OF DR. LINDEN S. BLUE, VICE CHAIRMAN OF THE BOARD, GA TECHNOLOGIES

Dr. **Blue**. Thank you, Madam Chairman. It is always good to talk to this Committee. I, of course, have written comments but I won't go through all those. I hope you will read them.

We have had some significant accomplishments this year, including meeting 128 milestones of the DOE and the NPR designation and, of course, the contract for the four-year program with the DOE.

But rather than belabor those points, I'd like to talk about what I think was the significant activity in the world in terms of nuclear energy for 1988, what the significant things will be for 1989, how the Modular HGTR will play in that, and what its full meaning will be.

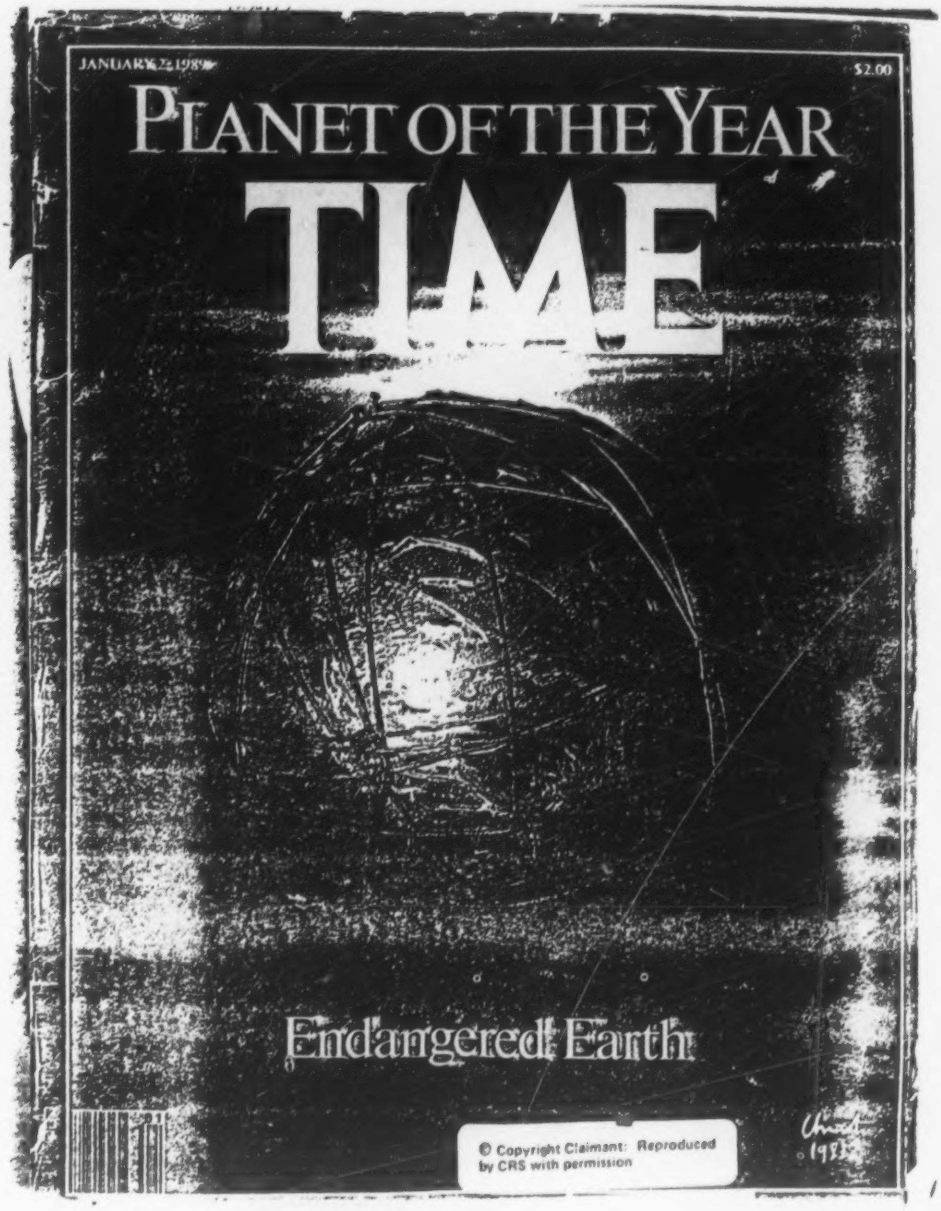
Then, finally, I'd like to take just a minute or two and talk about the thermionic fuel elements which we also do.

First of all, I think 1988 was best capsulized, if you will, by the Time Magazine cover story about Energy and the Environment. It brought it into an international focus. It showed that either the world has to respond to these problems or it is going to be in a serious shape.

Of course, the fact that they concluded that nuclear was an essential part of the energy equation was the sort of thing that we would agree with, and we were delighted that they chose the Modular HGTR as the ideal nuclear technology.

Mrs. LLOYD. Dr. Blue, if I may interrupt, I would like to have a copy of the article of Time Magazine, without objection, to be a part of the hearings, the record of today's hearings.

[The article mentioned above follows:]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PLANET OF THE YEAR
TIME
Endangered Earth
1988

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Vol. 133 No. 1

TIM

THE WEEKLY NEWS AZINE

PLANET OF THE YEAR: With drought, famine and fouled beaches, the earth warns of environmental disaster 24

This wondrous globe has endured for some 4.5 billion years, but its future is clouded by man's reckless ways: overpopulation, pollution, waste of resources and wanton destruction of natural habitats. TIME analyzes the looming ecological crisis and provides an agenda for urgent action.

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94 Cinema
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105 People

Cover:
Wrapped Globe, 19[illegible] by Christo,
photographed by Gianfranco Gorgoni

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JANUARY 2, 1989

From the Publisher

Journalists and experts came together at the TIME Environment Conference in Boulder

This week's unorthodox choice of Endangered Earth as Planet of the Year, in lieu of the usual Man or Woman of the Year, had its origin in the scorching summer of 1988, when environmental disasters—droughts, floods, forest fires, polluted beaches—dominated the news. By August TIME knew it was no longer enough just to describe familiar problems one more time. "The new journalistic challenge," says managing editor Henry Muller, "was to help find solutions, and that by definition meant international solutions." So we invited a distinguished group of scientists, administrators and political leaders from five continents to a TIME conference charged with producing a tough but realistic action program. The conference was organized by Washington correspondent Dick Thompson. His proudest coup was to persuade a team of Soviet experts to participate. The group was led by Fyodor Morgun, Mikhail Gorbachev's hand-picked chairman of the state committee for environmental protection.

Even before Thompson's preparations were complete, our editors decided that the growing concern about the planet's future had become the year's most important story. Thus was born the idea of using the conference as the centerpiece of this week's 33-page package, which was coordinated by sciences editor Charles Alexander. It is not the first time the magazine has recognized something other than humans in its Man of the Year issue. In 1982 it named the computer Machine of the Year.

The Environment Conference was an extraordinary event, set in appropriately pristine surroundings: the foothills of Boulder, where the Great Plains meet the Rocky Mountains. For three days in November, 26 TIME journalists and 33 experts engaged in an interchange of ideas that was as freewheeling as it was productive. The meetings took place at the National Center for Atmospheric Research, whose staff helped plan the agenda. The Soviets were particularly open in what they revealed both about their country's environmental woes and on a personal level. At one point Thompson challenged Morgun to a game of eight ball on a barroom pool table in Juanita's, a Mexican restaurant. To his shock, Thompson not only got his match, but was soundly beaten.

Christo with the world in his hands

While a team of writers and researchers worked on the stories back in New York City, art director Rudy Hoglund and deputy director Arthur Hochstein, who designed the layouts for the entire package, faced a difficult problem: how to create a strikingly original cover image. Their solution was to approach Christo, the famed Bulgarian-born environmental sculptor. In earlier works Christo had draped in plastic large sections of the earth—a stretch of Australian coast, a canyon in Colorado—but never the whole planet. This time Christo bundled a 16-in. globe in polyethylene and rag rope and drove more than 350 miles up and down New York's Long Island in search of the perfect combination of light and sea for a photograph. The result—Wrapped Globe 1988—is a fitting symbol of earth's vulnerability to man's reckless ways.

Robert L. Mill

CONFERENCE PARTICIPANTS

Saad Baba Third Secretary, Nigerian Mission to the United Nations **Robert Berg** President, International Development Conference, Washington **Lester Brown** President, Worldwatch Institute, Washington **José Pedro de Oliveira Costa** Professor of Environmental Planning, University of São Paulo, Brazil **John Eddy** Director, Office for Interdisciplinary Earth Studies, University Corporation for Atmospheric Research, Boulder **Christopher Gakahu** Conservation Biologist, Wildlife Conservation International, Nairobi **Murray Gell-Mann** Professor of Theoretical Physics, California Institute of Technology **Michael Glantz** Head, Environmental and Societal Impacts Group, National Center for Atmospheric Research, Boulder **Eric Goldstein** Director, Urban Environment Program, Natural Resources Defense Council, New York City **Albert Gore Jr.** U.S. Senator, Tennessee **Daniel Janzen** Professor of Biology, University of Pennsylvania **Brice Lalonde** Under Secretary for the Environment, France **Thomas Lovejoy** Assistant Secretary for External Affairs, Smithsonian Institution, Washington **Berrien Moore III** Director, Institute for the Study of Earth, Oceans and Space, University of New Hampshire **Fyodor Morgun** Chairman, State Committee for Environmental Protection, U.S.S.R. **Takahisa Nemoto** Director, Ocean Research Institute, University of Tokyo **Paulo Nogueira-Neto** Environmental Adviser, Ministry of Culture, Brazil **Vasili Peskov** Correspondent, *Komsomolskaya Pravda*, Moscow **Kenneth Piddington** Director, Environment Department, World Bank, Washington **J. Winston Porter** Assistant Administrator for Solid Waste and Emergency Response, U.S. Environmental Protection Agency **David Rall** Director, National Institute of Environmental Health Sciences, Research Triangle Park, N.C. **Peter Raven** Director, Missouri Botanical Garden, St. Louis **Nicholas Robinson** Professor, Pace University School of Law, White Plains, N.Y. **Phillip Rooney** President and Chief Operating Officer, Waste Management Inc., Oak Brook, Ill. **Vladimir Sokharov** Deputy Chief of International Cooperation, State Committee for Environmental Protection, U.S.S.R. **Stephen Schneider** Head, Interdisciplinary Climate Systems Group, National Center for Atmospheric Research, Boulder **James Gustave Speth** President, World Resources Institute, Washington **Sir Crispin Tickell** British Permanent Representative, United Nations **Alvaro Umaña** Minister of Industry, Energy and Mines, Costa Rica **B.B. Vohra** Vice Chairman, Himachal Pradesh State Land Use Board, New Delhi **Bruce Wilcox** President, Institute for Sustainable Development, Palo Alto, Calif. **E.O. Wilson** Frank B. Baird Jr. Professor of Science, Harvard University **Timothy Wirth** U.S. Senator, Colorado

FLOODS IN BANGLADESH: This year the earth spoke, like God warning Noah of the deluge, and people began to listen

BY THOMAS A. SANCTON

One generation passeth away, and another generation cometh: but the earth abideth forever.
—Ecclesiastes

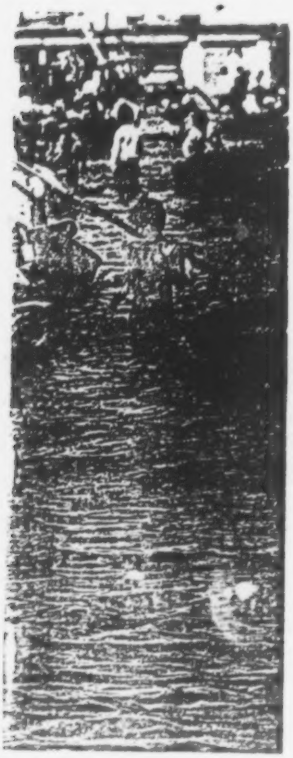
No, not forever. At the outside limit, the earth will probably last another 4 billion to 5 billion years. By that time, scientists predict, the sun will have burned up so much of its own hydrogen fuel that it will expand and incinerate the surrounding planets, including the earth. A nuclear cataclysm, on the other hand, could destroy the earth tomorrow. Somewhere within those extremes lies the life expectancy of this wondrous, swirling globe. How long it endures and the quality of life it can support do not depend alone on the immutable laws of physics. For man has reached a point in his evolution where he has the power to affect, for better or worse, the present [illegible] future state of the planet.

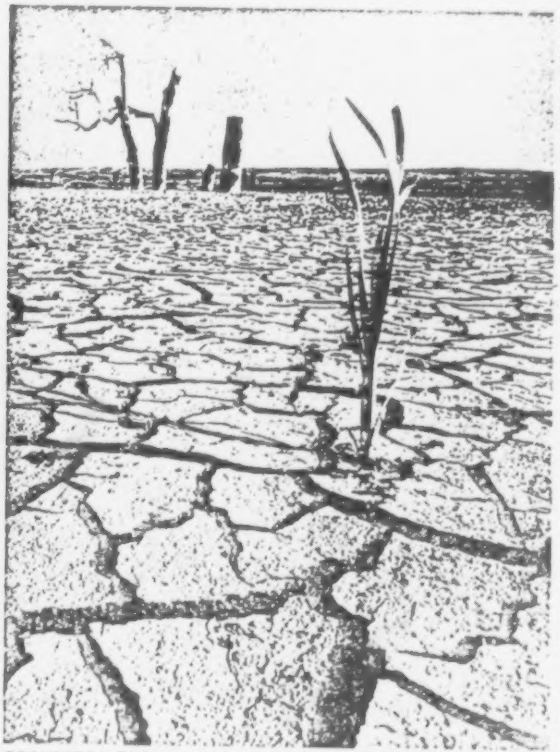
Through most of his 2 million years or so of existence, man has thrived in earth's environment—perhaps too well. By 1800 there were 1 billion human beings bestriding the planet. That number had doubled by 1930 and doubled again by 1975. If current birth rates hold, the world's present population of 5.1 billion will double again in 40 more years. The frightening irony is that this exponential growth in the human population—the very sign of homo sapiens' success as an organism—could doom the earth as a human habitat.

The reason is not so much the sheer numbers, though 40,000 babies die of starvation each day in Third World countries, but the reckless way in which humanity has treated its planetary host. Like the evil genies that flew from Pandora's box, technological advances have provided the means of upsetting nature's equilibrium, that intricate set of biological, physical and chemical interactions that make up the web of life. Starting at the dawn of the Industrial Revolution, smokestacks have disgorged noxious gases into the atmosphere, factories have dumped toxic wastes into rivers and streams, automobiles have guzzled irreplaceable fossil fuels and fouled the air with their detritus. In the name of progress, forests have been denuded, lakes poisoned with pesticides, underground aquifers pumped dry. For decades, scientists have warned of the possible consequences of all this profligacy. No one paid much attention.

This year the earth spoke, like God warning Noah of the deluge

Photo on preceding pages by H. Silvester—Rapho





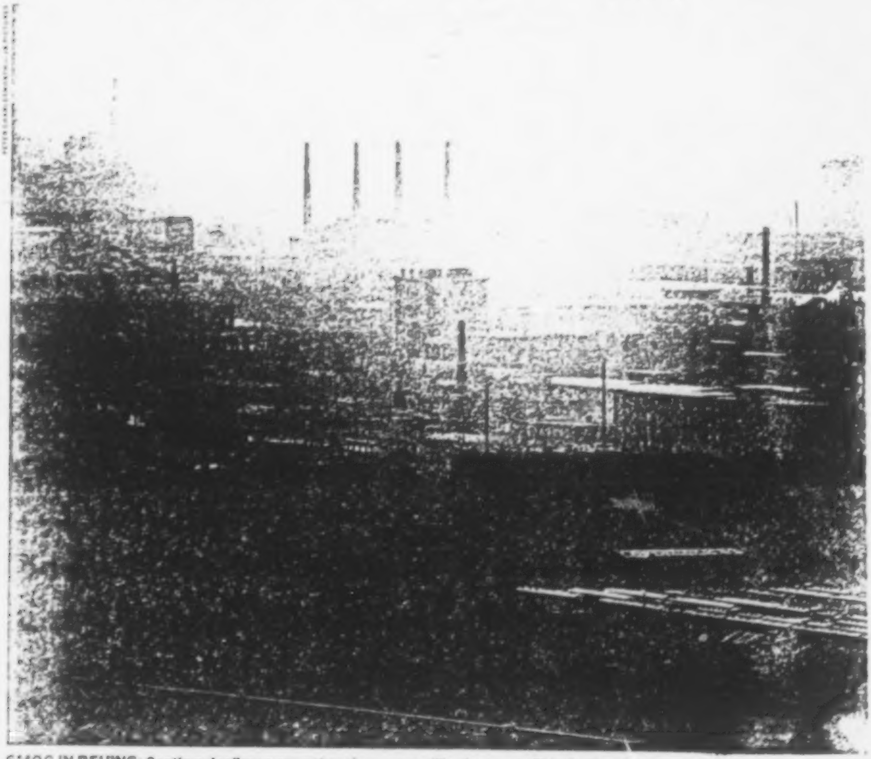
DROUGHT IN NORTH DAKOTA: Dry heat and fears of global warming

Its message was loud and clear, and suddenly people began to listen, to ponder what portents the message held. In the U.S., a three-month drought baked the soil from California to Georgia, reducing the country's grain harvest by 31% and killing thousands of head of livestock. A stubborn seven-week heat wave drove temperatures above 100°F across much of the country, raising fears that the dreaded "greenhouse effect"—global warming as a result of the buildup of carbon dioxide and other gases in the atmosphere—might already be under way. Parched by the lack of rain, the Western forests of the U.S., including Yellowstone National Park, went up in flames, also igniting a bitter conservationist controversy. And on many of the country's beaches, garbage, raw sewage and medical wastes washed up to spoil the fun of bathers and confront them personally with the growing despoliation of the oceans.

Similar pollution closed beaches on the Mediterranean, the North Sea and the English Channel. Killer hurricanes ripped through the Caribbean and floods devastated Bangladesh, reminders of nature's raw power. In Soviet Armenia a monstrous earthquake killed some 55,000 people. That too was a natural disaster, but its high casualty count, owing largely to the construction of cheap high-rise apartment blocks over a well-known fault area, illustrated the carelessness that has become humanity's habit in [illegible] nature.

There were other forebodings of environmental [illegible] the U.S. it was revealed that federal weapons-making [illegible] recklessly and secretly littered large areas with radio[illegible] The further depletion of the atmosphere's ozone layer, which [illegible] block cancer-causing ultraviolet rays, testified to the continued overuse of atmosphere-destroying chlorofluorocarbons emanating from such sources as spray cans and air-conditioners. Perhaps most ominous of all, the destruction of the tropical forests, home to at least half the earth's plant and animal species, continued at a rate equal to one football field a second.

Most of these evils had been going on for a long time and some of the worst disasters apparently had nothing to do with human behavior. Yet this year's bout of freakish weather and environmental horror stories seemed to act as a powerful catalyst for worldwide public opinion. Everyone suddenly sensed that this gyrating globe, this precious repository of all the life that we know of, was in danger. No single individual, no event, no movement captured imaginations or dominated headlines more than the clump of rock and soil and water and air that is our common



SMOG IN BEIJING: Continued reliance on vast coal reserves will only worsen China's air pollution

home. Thus in a rare but not unprecedented departure from its tradition of naming a Man of the Year, TIME has designated Endangered Earth as Planet of the Year for 1988.

To help focus its coverage, TIME invited 33 scientists, administrators and political leaders from ten countries to a three-day conference in Boulder in November. The group included experts in climate change, population, waste disposal and the preservation of species. In addition to explaining the complexities of these interlocking problems, the specialists advanced a wide range of practical ideas and suggestions that TIME has fashioned into an agenda for environmental action. That agenda, accompanied by stories on each of the major environmental problems, appears throughout the following pages.

What would happen if nothing were done about the earth's imperiled state? According to computer projections, the accumulation of CO_2 in the atmosphere could drive up the planet's average temperature 3° F to 9° F by the middle of the next century. That could cause the oceans to rise by several feet, flooding coastal areas and ruining huge tracts of farmland through salinization. Changing weather patterns could make huge areas infertile or uninhabitable, touching off refugee movements unprecedented in history.

Toxic waste and radioactive contamination could lead to shortages of safe drinking water, the sine qua non of human existence. And in a world that could house between 8 billion and [illegible] billion people by the mid-21st century, there is a strong likelihood of mass starvation. It is even possible to envision the world as was chillingly prophesied by the typewriting cockroach in Don Marquis' *archy and mehitabel*: "man is making deserts of the earth/ it wont be long now/ before man will have it used up/ so that nothing but ants/ and centipedes and scorpions/ can find a living on it."

There are those who believe the worst scenarios are alarmist and ill founded. Some scientists contest the global-warming theory or predict that natural processes will counter its effects. Kenneth E.F. Watt, professor of environmental studies at the University of California at Davis, has gone so far as to call the greenhouse effect "the laugh of the century." S. Fred Singer, a geophysicist working for the U.S. Department of Transportation, predicts that any greenhouse warming will be balanced by an increase in heat-reflecting clouds. The skeptics could be right, but it is far too risky to do nothing while awaiting absolute proof of disaster.

Whatever the validity of this or that theory, the earth will not remain as it is now. From its beginnings as a chunk of molten

FAMINE IN MOZAMBIQUE: 40,000 babies starve to death each day

rock and gas some 4.5 billion years ago, the planet has seen continents form, move together and drift apart like jigsaw-puzzle pieces. Successive ice ages have sent glaciers creeping down from the polar caps. Mountain ranges have jutted up from ocean beds, and landmasses have disappeared beneath the waves.

Previous shifts in the earth's climate or topology have been accompanied by waves of extinctions. The most spectacular example is the dying off of the great dinosaurs during the Cretaceous period (136 million to 65 million years ago). No one knows exactly what killed the dinosaurs, although a radical change in environmental conditions seems a likely answer. One popular theory is that a huge meteor crashed to earth and kicked up such vast clouds of dust that sunlight was obscured and plants destroyed. Result: the dinosaurs starved to death.

Whether or not that theory is correct, an event of no less magnitude is taking place at this very moment, but this time its agent is man. The wholesale burning and cutting of forests in Brazil and other countries, as one major example, are destroying irreplaceable species every day. Says Harvard biologist E.O. Wilson: "The extinctions ongoing worldwide promise to be at least as great as the mass extinction that occurred at the end of the age of dinosaurs."

Humanity's current predatory relationship with nature reflects a man-centered world view that has evolved over the ages. Almost every society has had its myths about the earth and its origins. The ancient Chinese depicted Chaos as an enormous egg whose parts separated into earth and sky, yin and yang. The Greeks believed Gaia, the earth, was created immediately after Chaos and gave birth to the gods. In many pagan societies, the earth was seen as a mother, a fertile giver of life. Nature—the soil, forest, sea—was endowed with divinity, and mortals were subordinate to it.

The Judeo-Christian tradition introduced a radically different concept. The earth was the creation of a monotheistic God, who, after shaping it, ordered its inhabitants, in the words of *Genesis*: "Be fruitful and multiply, and replenish the earth and subdue it: and have dominion over the fish of the sea and over the fowl of the air and over every living thing that moveth upon the earth." The idea of dominion could be interpreted as an invitation to use nature as a convenience. Thus the spread of Christianity, which is generally considered to have paved the way for the development of tech-

DEATH IN THE NORTH SEA: Their immune systems weakened by pollution, thousands of seals died of pneumonia

PHOTOREPORTERS

nology, may at the same time have carried the seeds of the wanton exploitation of nature that often accompanied technical progress.

These tendencies were compounded by the Enlightenment notion of a mechanistic universe that man could shape to his own ends through science. The exuberant optimism of that world view was behind some of the greatest achievements of modern times: the invention of laborsaving machines, the discovery of anesthetics and vaccines, the development of efficient transportation and communication systems. But, increasingly, technology has come up against the law of unexpected consequences. Advances in health care have lengthened life-spans, lowered infant-mortality rates and, thus, aggravated the population problem. The use of pesticides has increased crop yields but polluted water supplies. The invention of automobiles and jet planes has revolutionized travel but sullied the atmosphere.

Yet the advance of technology has never destroyed man's wonder and awe at the beauty of the earth. The coming of England's Industrial Revolution, with its "dark Satanic mills," coincided with the extraordinary flowering of Romantic poetry, much of it about the glory of nature. Many people in this century [illegible] the same tender feelings on seeing the first images of the earth as viewed from the moon. The sight of that shimmering, luminescent ball set against the black void inspired even normally prosaic astronauts to flights of eloquence. Edgar Mitchell, who flew to the moon aboard Apollo 14 in 1971, described the planet as "a sparkling blue-and-white jewel . . . laced with slowly swirling veils of white . . . like a small pearl in a thick sea of black mystery." Photos of the earth from space prompted geologist Preston Cloud to write, "Mother Earth will never seem the same again. No more can thinking people take this little planet . . . as an infinite theater of action and provider of resources for man, yielding new largesse to every demand without limit." That conclusion seems all the more imperative in the wake of the environmental shocks of 1988.

Let there be no illusions. Taking effective action to halt the massive injury to the earth's environment will require a mobilization of political will, international cooperation and sacrifice unknown except in wartime. Yet humanity is in a war right now, and it is not too Draconian to call it a war for survival. It is a war in which all nations must be allies. Both the causes and effects of the problems that threaten the earth are global, and they must be attacked globally. "All nations are tied together as to their common fate," observes Peter Raven, director of the Missouri Botanical Garden. "We are all facing a common problem, which is, How are we going to keep this single resource we have, namely the world, viable?"

As man heads into the last decade of the 20th century, he finds himself at a crucial turning point: the actions of those now living will determine the future, and possibly the very survival, of the species. "We do not have generations, we only have years in which to attempt to turn things around," warns Lester Brown, president of the Washington-based Worldwatch Institute. Every individual on the planet must be made aware of its vulnerability and of the urgent need to preserve it. No attempt to protect the environment will be successful in the long run unless ordinary people—the California housewife, the Mexican peasant, the Soviet factory worker, the Chinese farmer—are willing to change their life-styles. Our wasteful, careless ways must become a thing of the past. We must recycle more, procreate less, turn off lights, use mass transit, do a thousand things differently in our everyday lives. We owe this not only to ourselves and our children but also to the unborn generations who will one day inherit the earth.

Mobilizing that sort of mass commitment will take extraordinary leadership, of the kind that has appeared before in times of crisis: Churchill's eloquence galvanizing his embattled countrymen to live "their finest hour," F.D.R.'s pragmatic idealism giving hope and jobs to Depression-ridden Americans. Now, more than ever, the world needs leaders who can inspire their fellow citizens with a fiery sense of mission, not a nationalistic or military campaign but a universal crusade to save the planet. Unless mankind embraces that cause totally, and without delay, it may have no alternative to the bang of nuclear holocaust or the whimper of slow extinction. ■

GREGORY DIMIJIAN—PHOTO RESEARCHERS

VANISHING FORESTS: Even Costa Rica's high-altitude cloud forests are now threatened by ranchers and farmers.

BIODIVERSITY

The Death of Birth

THE PROBLEM: Man is recklessly wiping out life on earth

BY EUGENE LINDEN

Before Brazil's great land rush, the emerald rain forests of Rondônia state were an unspoiled showcase for the diversity of life. In this lush territory south of the Amazon, there was hardly a break in the canopy of 200-ft.-tall trees, and virtually every acre was alive with the cacophony of all kinds of insects, birds and monkeys. Then, beginning in the 1970s, came the swarms of settlers, slashing and burning huge swaths through the forest to create roads, towns and fields. They came to enjoy a promised land, but they have merely produced a network of devastation. The soil that supported a rich rain forest is not well suited to corn and other crops, and most of the newcomers can eke out only an impoverished, disease-ridden existence. In the process, they are destroying an ecosystem and the millions of species of plants and animals that live in it. An estimated 20% of Rondônia's forest is gone, and at present rates of destruction it will be totally wiped out within 25 years.

Around the globe, on land and in the sea, the story is much the same. Spurred by poverty, population growth, ill-advised policies and simple greed, humanity is at war with the plants and animals that share its planet. Peter Raven, director of the Missouri Botanical Garden, predicts that during the next three decades man will drive an average of 100 species to extinction every day. Extinction is part of evolution, but the present rate is at least 1,000 times the pace that has prevailed since prehistoric times.

Even the mass extinctions 65 million years ago that killed off the dinosaurs and countless other species did not significantly affect flowering plants, according to Harvard biologist Edward O. Wilson. But these plant species are disappearing now, and humans, not comets or volcanoes, are the angels of destruction. Moreover, the earth is suffering the decline of entire ecosystems—the nurseries of new life-forms. For that reason, Wilson deems this crisis the "death of birth." British ecologist Norman Myers has called it the "greatest single setback to life's abundance and diversity since the first flickerings of life almost 4 billion years ago."

Nearly every habitat is at risk. Forests in the northern hemisphere have fallen to lumbering, development and acid rain. Marine ecosystems around the world are threatened by pollution, overfishing and coastal development. It is in the tropics, though, that the battle to preserve what scientists call biodiversity will be won or lost. Tropical forests cover only 7% of the earth's surface, but they house between 50% and 80% of the planet's species.

But should people in developed countries care about the survival of tropical species never seen outside a rain forest? Yes, they should. Variety is the spice of life, goes the saying. Biologists

ENDANGERED:
Golden-Headed Tamarin
No one knows how many of these primates remain in ragged remnants of Brazil's once vast coastal forests.

ENDANGERED:
Day Gecko
Native to an island near Mauritius, in the Indian Ocean, this type of gecko is losing its habitat

ENDANGERED:
Snow Leopard
Despite protection, the big cat is hunted in Central Asia for its soft, beautiful pelt

would go further and argue that variety is the very stuff of life. Life needs diversity because of the interdependencies that link flora and fauna, and because variation within species allows them to adapt to environmental challenges. But even as the world's human population explodes, other life is ebbing from the planet. Humanity is making a risky wager—that it does not need the great variety of earth's species to survive.

Despite the alarm with which scientists view this trend, biodiversity has just surfaced on the world's political agenda. The troubles of high-profile animals such as the tiger and rhino grab public attention, while most people hardly see the point of worrying about insects or plants. But extinction is the one environmental calamity that is irreversible. As these lowly species disappear unnoticed, they take with them hard-won lessons of survival encoded in their genes over millions of years.

Only 1.7 million of the estimated 5 million to 30 million different life-forms on earth have been cataloged. Since hundreds of thousands of species may be extinct by the year 2000, the world has neither the scientists nor the time to identify the yet uncounted. "It's as though the nations of the world decided to burn their libraries without bothering to see what is in them," said University of Pennsylvania biologist Daniel Janzen at the TIME conference. Harvard's Wilson called this profligacy the "folly" that future generations are least likely to forgive.

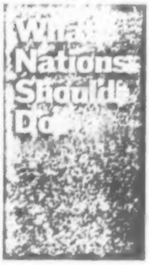
Humanity already benefits greatly from the genetic heritage of little-known species. Some 25% of the pharmaceuticals in use in the U.S. today contain ingredients originally derived from wild plants. Hidden anonymously in clumps of vegetation about to be bulldozed or burned might be plants with cures for still unconquered diseases. "I know of three plants with the potential to treat AIDS," said Janzen. "One grows in an Australian rain forest, one in Panama and one in Costa Rica."

Nature's diversity offers many opportunities for agriculture, especially now that genetic mapping and engineering have given biotechnology firms the potential power to improve crops by transferring genes from wild strains. According to Wilson, biotechnology can transform a plant into a "loose-leaf notebook" from which scientists can select a particular page. Among the possible results: drought- and frost-resistant crops, and natural fertilizers and pesticides.

Diversity is the raw material of earth's wealth, but nature's true creativity lies in the relationships that link various creatures. The coral in a reef or the orchid in a rain forest is part of an ecosystem, a fragile, often delicately balanced conglomeration of supports, checks and balances that integrate life-forms into functioning communities. Given the complex workings of an ecosystem, it is never clear which species, if any, are expendable.

In the tropics the crucial question is how large a forest must be to sustain itself. If a park or protected area is too small to support some of its animal and plant life, the ecosystem will decline even with protection. As yet, no one knows the minimum critical size of a rain forest, but in 1979 Thomas Lovejoy, now at the Smithsonian Institution, set up a 20-year experiment with the cooperation of the Brazilian government to determine just that for the Amazon region. Among the findings: the smaller the forest, the faster the decline of insects, birds and mammals.

Biologists have identified numerous "hot spots" where



1. **Develop local organizations and educational programs to impress upon people the value of genetic diversity and the irreversible damage that occurs when species are wiped out.**

2. **Establish comprehensive national zoning plans so that preservation goes hand in hand with development.**

3. **Set up projects to demonstrate that tropical forests and other endangered habitats can be developed—and yield economic returns—without being destroyed.**

4. **Make environmental review an integral part of lending procedures within nations so that local banks are prevented from providing funds for projects that destroy habitats.**

5. **Increase funding to develop zoos and other "gene banks" as places where species can be perpetuated.**

JOHNNY JOHNSON—ANIMALS ANIMALS

ENDANGERED:
Bald Eagle
The U.S. national bird has ever fewer refuges from hunters and poisonous pesticides

RAYMOND MENDEZ

ENDANGERED:
Harlequin Beetle
Found in Central and South American rain forests, the beetle breeds in trees that are fast disappearing

PETER LOWRY

ENDANGERED:
Symphonia
This plant clings to survival in Madagascar, where 90% of the original vegetation has been destroyed

systems are under attack and large numbers of unique species face an immediate threat of elimination. Among the troubled areas: Madagascar, where more than 90% of the original vegetation has disappeared; the monsoon forests of the Himalayan foothills that are being denuded by villagers in search of firewood, building materials and arable land; New Caledonia, 83% of whose plants occur nowhere else; the eastern slope of the Andes, as well as forests in East Africa, peninsular Malaysia, northeast Australia and along the Atlantic coast of Brazil.

Since less than 5% of the world's tropical forests receive any protection, the stage is set for mass extinctions. Many plants and animals are doomed, no matter what measures are taken. Some researchers estimate that at least 12% of the bird species in the Amazon basin, as well as 15% of the plants in Central and South America, can be counted among what Janzen calls the "living dead." Many tropical mammals and reptiles face only bleak survival under what amounts to house arrest in game parks and zoos.

Why are so many species and environments threatened? The main reason is that throughout the tropics, developing nations are struggling to feed their peoples and raise cash to make payments on international debts. Many countries are chopping down their forests for the sake of timber exports. In Central America forests are giving way to cattle ranches, which supply beef to American fast-food chains. The pressures on forests have led Janzen, who has spent 26 years struggling to save Costa Rica's woodlands, to conclude that "everything outside parks will be gone, and everything inside the parks is threatened."

Efforts to stop the destruction run into moral as well as practical obstacles. How can developed nations demand onerous debt payments and ask the debtors to preserve their forests? How can countries worry about biodiversity when their people are concerned with feeding themselves?

To begin with, the rich nations must reduce the debt burden of the poor. But just as important is a concerted campaign to convince the people of developing countries that it is in their own long-term interest to preserve their environments. Wiping out forests may make developing nations momentarily richer, but it is bound to produce a poorer future.

Experience has shown the Third World that destruction of forests can have disastrous consequences. Forests are vital watersheds that absorb excess moisture and anchor topsoil. Deforestation contributed to the recent droughts in Africa and the devastating mud slides in Rio de Janeiro last year. In Costa Rica topsoil eroded from bald hills has greatly shortened the life of an expensive hydroelectric dam. Alvaro Umaña, Costa Rica's Minister of Industry, Energy and Mines, estimated that the surrounding watershed might have been protected 20 years ago for a cost of $5 million. Now the government must reforest the watershed at ten times that price.

Halting the assault on biodiversity will not be easy, but there are many actions that governments can take. First, they should develop and support local scientific institutions that train professionals in conservation technology. More money should flow into educational programs that alert people to the irreversible consequences of a loss of genetic diversity. An international, environmental version of the Peace Corps could lend conservation expertise to the Third World.

Throughout the developing nations there are encouraging stirrings of local environmental activity. In Malaysia blowgun-armed Penan tribesmen have joined forces with environmentalists in an effort to stop rampant logging. And in Brazil, which has some 500 conservation organizations, environmentalist José Pedro de Oliveira Costa organized a coalition of legislators, conservationists, industrialists and media barons to stir public support to preserve Brazil's remaining Atlantic forests. "The threats to the forests remain," said Costa, "but now at least there is a network in place to scream when a threat arises."

But environmental protection must

Dividends From Diversity

Few Americans realize how often exotic plants and animals yield unexpected benefits. Some examples:

- **Squibb used the venom of the Brazilian pit viper to develop Capoten, a drug for high blood pressure.**
- **By transplanting genes from tropical tomatoes, the NPI biotech firm increased the density of U.S. tomatoes 2%, promising catsup manufacturers extra profits.**
- **Scientists believe that arcelin, a natural protein in wild Mexican beans that repels insects, might protect some U.S. crops without poisoning soil and water.**
- **Future newspapers may be printed on paper from kenaf, an African plant that can produce five times as much pulp an acre than the trees normally cut for newsprint.**

ENDANGERED:
Western Tragopan
Native to Himalayan mountain forests, this bird is vulnerable to peasants who cut trees for fuel

ENDANGERED:
San Rafael Cactus
One of many U.S. plants in jeopardy, the cactus is besieged by development and collectors.

ENDANGERED:
Drill
Hunting and deforestation have reduced this monkey's territory to remote forests in Cameroon.

make economic sense, and development must go hand in hand with preservation. Development should be sustainable, meaning that it should use up resources no faster than they can be regenerated by nature. Governments and private firms should organize projects to show that forests can be used without being obliterated. If trees are cut selectively, forests can yield profits and survive to produce more money in the future. Another way to harvest cash from forests and other habitats is to set up tours and safaris to attract animal lovers and photography buffs. Long a moneymaker in Africa and the Galápagos Islands, this "ecotourism" is spreading to such places as Costa Rica.

For sustainable development to work, observed Paulo Nogueira-Neto, environmental adviser to the Brazilian Ministry of Culture, governments will have to devise comprehensive national zoning plans so that their countries can achieve the right mix of preservation and economic growth. Local residents can be encouraged to earn a livelihood in the more robust areas, while habitats that are fragile can be protected. Sustainable development can proceed, noted Kenneth Piddington, director of the environmental department of the World Bank, "right up to a park's boundary."

Financial as well as political leverage can be used in the cause of preservation. Governments should force local lending institutions to review the environmental consequences of proposed loans. No bank, for example, should be allowed to lend a company money to set up a cattle ranch if the operation would destroy too large a section of an endangered forest.

Finally, the unfortunate reality is that many habitats are not going to be saved. To prevent the genetic legacy of those areas from being extinguished, as many species as possible should be preserved in zoos, botanical gardens and other "gene banks." There, scientists can study a small percentage of threatened organisms and have the options of later returning them to the wild or transplanting some of their genes into other species.

But the best place to preserve the earth's biodiversity is in the ecosystems that gave rise to it. Man must abandon the belief that the natural order is mere stuff to be managed and domesticated, and accept that humans, like other creatures, depend on a web of life that must be disturbed as little as possible. ■

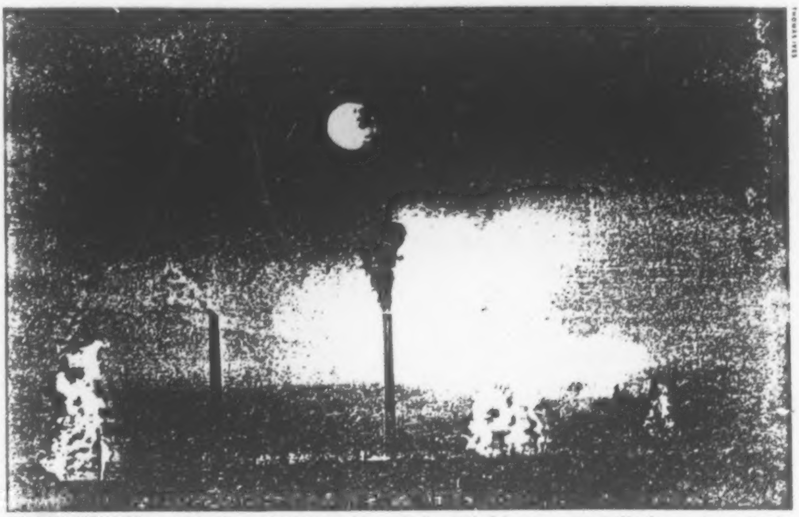
The Good News: Costa Rica Guards Its Forests

When a fungal disease began ravaging Levy Bryant's four-hectare cacao farm a decade ago, the landowner could have done what other besieged farmers have done. He might easily have picked up an ax and begun cutting down more tropical rain forest around his land on Costa Rica's Caribbean coast. He could have sold the timber from the tall laurel trees that shade the cacao bushes, then burned the dense virgin forest on the hill behind his farm. Then Bryant, like so many financially strapped small farmers in Latin America, could have sown pasture and sold the land to a cattle rancher. Within three or four years, one more small piece of the tropics would have vanished.

That Bryant did not rush headlong down this slippery ecological slope is in part testimony to Costa Rica's commitment to its dwindling natural resources. The country has more than 20 national parks, wildlife preserves and other protected areas covering 2,577 sq. mi., or 13% of the land. Moreover, the nation's stable democracy has attracted hundreds of scientists and ecologists, making Costa Rica a laboratory for finding out what is possible in terms of sustainable development in the tropics.

One of the major reasons Bryant's plantation is not a fast-eroding cow pasture is that he got help from an environmental group called Anai (which means "friend" in the language of the local Bribri Indians). "We probably wouldn't still be farming if it wasn't for these guys," admits Bryant. Anai provided him with new kinds of crops, including vanilla plants and a different variety of cacao tree, which is less likely to die from fungus. Over the past five years, Anai has brought dozens of new varieties of cash crops to more than 20 communities in the Talamanca region, set up plant nurseries serving 1,500 people, and helped establish a 10,000-hectare wildlife refuge.

The encroachment of cow pastures on the cloud forest at Monteverde spurred another of Costa Rica's [illegible] to save its natural heritage. In [illegible] hectares of land owned by American Quakers who had settled the region in the 1950s were set aside as a private reserve. Over the years that has grown to 10,500 hectares. One key to preserving this huge area was to allow local people to develop a tourist business. In five years the annual number of visitors has gone from 6,000 to 15,000, and could climb to more than 30,000 when a new road up from the plain is built. The success shows that forests can produce income without being destroyed.



HIDDEN MENACE: Invisible CO_2 emitted along with smoke from this Arizona copper smelter is warming up the air

GLOBAL WARMING

Feeling the Heat

THE PROBLEM: Greenhouse gases could create a climatic calamity

BY MICHAEL D. LEMONICK

For more than a decade, many scientists have warned that cars and factories are spewing enough gases into the atmosphere to heat up the earth in a greenhouse effect that could eventually produce disastrous climate changes. But until recently, the prophets of global warming garnered about as much attention as the religious zealots who insist that Armageddon is near. When Colorado Senator Timothy Wirth held congressional hearings on the greenhouse effect in the fall of 1987, the topic generated no heat at all. "We had a very, very distinguished panel," Wirth recalled at the TIME Environment Conference, "and who was in the cavernous hearing room? Six or seven people, and two or three of them were lost tourists."

So Wirth decided to schedule another hearing in the summer, hoping hot weather would make people pay attention to the greenhouse issue. Sure enough, when the hearing convened last June 23, the thermometer read 99° F, a Washington record for that day. The room was packed when James Hansen, head of NASA's Goddard Institute for Space Studies, turned global warming into front-page news at last. "It is time to stop waffling so much," he declared. "The evidence is pretty strong that the greenhouse effect is here."

Hansen thus became perhaps the most prominent scientist willing to say straight out that the earth-warming effect of excess carbon dioxide (CO_2) and other gases generated by industry and agriculture had crossed the line from theory into fact itself. Hansen's bold assertion was dramatic enough. But the unusual string of weather-related disasters that struck the U.S. last summer could not have been better timed to drive the point home. The heat waves, droughts, floods and hurricanes could be previews of what could happen with ever increasing frequency if the atmosphere warms 3° F to 8° F by the middle of the next century, as some scientists predict.

On the other hand, the summer's disasters may have had nothing to do with the greenhouse effect. They could have been random events—all part of the natural year-to-year variations in weather. Many climatologists called Hansen's remarks premature and feared that if this summer happens to be cool, public worries about the greenhouse effect will quickly fade.

Unfortunately, scientists cannot agree on how much global warming has occurred, how much more is on the way and what the climatic consequences will be, giving policymakers an excuse for delay. But no one disputes the fact that the amount of CO_2 in the atmosphere has risen and continues to increase rapidly and that the human race is thus conducting a dangerous experiment

GAS GUZZLING: A Bangkok tie-up symbolizes growing Third World energy demands, which hurt efforts to cut fossil-fuel use

IOWA'S FUTURE? Climate change could erode land into dunes like these in Somalia

on an unprecedented scale. The possible consequences are so scary that it is only prudent for governments to slow the buildup of CO_2 through preventive measures, from encouraging energy conservation to developing alternatives to fossil fuels.

Some forecasters have suggested that the impact of global warming will not be uniformly bad around the world. After all, Canada would not complain if the productive corn-growing lands of the U.S. Midwest shifted north across the border, and the Soviet Union might welcome a warmer, more hospitable Siberia. But while the broad outlines of a hotter world are easy to draw, more specific projections are riddled with uncertainty, since the regional weather patterns that would prevail are largely unpredictable. If Canada becomes much dryer than it is now, for example, higher temperatures will not help much.

Moreover, while some nations will probably end up with a more benign climate than they now have, the pace of change could be so jarring that the benefits would be lost. "We're talking about rates of climate change perhaps 100 times faster than at any time in human history," said Stephen Schneider of the National Center for Atmospheric Research. Ecosystems will not be able to adjust so quickly, he said, "and the faster things change, the more likely it is that the impact will be negative." Warned Thomas Lovejoy of the Smithsonian Institution: "There will be no winners in this game of ecological chairs, for it will be fundamentally disruptive and destabilizing, and we can anticipate hordes of environmental refugees dwarfing the numbers of the Dust Bowl era or the boat people."

Ironically, the same greenhouse effect that may be so dislocating [illegible] hospitable to life in the first place. Without a heat-[illegible] blanket of naturally occurring CO_2, the planet would have an average surface temperature of only 0° F instead of 59° F. Reason: like the glass panes of a greenhouse, CO_2 molecules are transparent to visible light, allowing the sun's rays to warm the earth's surface. But when the surface gives off its excess heat, it does so not with visible light but with infrared radiation. And since CO_2 absorbs infrared rays, some of the excess heat stays in the atmosphere rather than escaping into space. How much heat is retained depends on how much CO_2 is in the air.

Recent research has confirmed that this is more than just theory. By drilling deep into Antarctic and Arctic ice, scientists have been able to measure the amount of CO_2 in air bubbles trapped in ancient layers of snow. They have also looked at fossilized plant tissues for clues as to how warm the air was during the same period. The [illegible] CO_2 levels and global temperatures have risen and fallen together, over tens of thousands of years. And there is evidence from space: Mars, which has little CO_2 in its atmosphere, has a surface temperature that reaches −24° F at best, while Venus, [illegible] of CO_2, is a hellish 850° F.

The ebb and flow of CO_2 on earth was caused by only [illegible] processes until less than 200 years ago. With the arrival of [illegible] dustrial Revolution in the early 1800s, man suddenly [illegible] a new factor into the climatic equation. Carbon dioxide is released in large quantities when wood and such fossil fuels as [illegible] and natural gas are burned. As society industrialized, [illegible] ing factories began releasing CO_2 faster than plants [illegible] which absorb the gas, could handle it. In the early 1960s [illegible] began burning oil and gas at prodigious rates. And [illegible]

What Nations Should Do

1. Impose special taxes on carbon-dioxide emissions, which would encourage energy conservation.

2. Increase funding for research on alternative energy sources, including solar power, and safer designs for nuclear reactors.

3. Provide financial aid to enable developing nations to build high-efficiency power plants rather than conventional facilities.

4. Launch a mammoth international tree-planting program.

5. Develop techniques for recovering part of the methane that is given off by landfills and cattle feedlots.

CLEAN POWER: Mirrors near San Diego focus sunlight to change water to steam, which drives electric generators

population led to the widespread cutting of trees in less developed countries. These trees are no longer available to soak up excess CO_2, and whether they are burned or left to rot, they instead release the gas. By the late 1800s atmospheric CO_2 had risen to between 280 and 290 parts per million. Today it stands at 350 p.p.m., and by 2050 it could reach 500 to 700 p.p.m., higher than it has been in millions of years.

But carbon dioxide, once thought to be exclusively responsible for the greenhouse effect, is now known to cause only half the problem. The rest comes from other gases. Chlorofluorocarbons, or CFCs, are not only destroyers of the stratosphere's ozone layer but powerful greenhouse gases as well. So are nitrogen oxides, which are pollutants spewed out of automobile exhausts and power-plant smokestacks. Another greenhouse gas is methane, the primary component of natural gas. Methane is also generated by bacteria living in the guts of cattle and termites, the muck of rice paddies and the rotting garbage in landfills. Each of these sources is fostered by human activity—even the termites, which thrive in the clearings left after tropical rain forests are cut down. Humanity's contribution to the greenhouse effect comes from so many basic activities that man cannot realistically expect to stop the process, only slow it down.

A first step toward doing that is to ban the production of CFCs, which are used to make plastic foam and as coolants in refrigerators and air conditioners. These gases account for an estimated 15% of the greenhouse effect. Another strategy is to burn as much methane as possible. That adds CO_2 to the air, but getting rid of the methane is well worth it. Both gases trap heat, but as a greenhouse gas, methane traps 20 times as much heat as carbon dioxide, molecule for molecule.

Methane from cattle feedlots will be very difficult to collect, but the gas in garbage landfills is already being tapped and burned at many sites around the U.S. At the Fresh Kills landfill on New York City's Staten Island, for example, methane that would otherwise have escaped into the air is being collected by a gas company and used to heat thousands of homes. The technique essentially involves driving a pipe into the depths of the garbage, then trapping the gas that rushes out. This should be done at all landfills.

Another step that could be taken to counteract global warming is to slow—and ideally stop—deforestation. But that is an enormously complex task, and so a simple companion strategy should be adopted at the same time: the planting of trees, and plenty of them, to absorb CO_2 from the air. "It surely has to be one of the most benign things we can do," said Gus Speth of the World Resources Institute. Tree planting can be encouraged at all levels of society, from individuals putting an extra tree or two in their backyards to local communities and private organizations planting an acre at a time to provincial and national governments reforesting on a more widespread basis.

Admittedly, trees are just a stopgap. Unless a tree is used for lumber, it eventually dies and rots or is burned, releasing whatever CO_2 it has absorbed. But since the rapid pace of change may be the greatest danger posed by global warming, stopgaps could be important. If nothing else, reforestation will buy time to put other preventive measures into place.

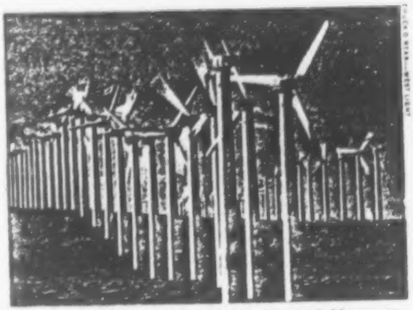
Tree planting will have negligible impact, however, if people continue to pump CO_2 into the atmosphere at current rates. While wood and fossil-fuel burning will never be eliminated, they can be cut down significantly. An immediate way to do so is through conservation. When oil prices soared in the 1970s, industries responded by becoming much more energy efficient. But the plunge in the price of oil from $36 per bbl. in 1982 to less than $12 per bbl. this fall has cooled the enthusiasm for conservation. Governments must rekindle that interest and boost energy saving by setting or raising minimum efficiency standards for automobiles, appliances and other machinery.

Although developed countries waste the most energy, there are plenty of opportunities for conservation in the developing world, where energy-using equipment tends to be older and more inefficient. Third World conservation would not only help slow greenhouse warming but also let countries save money by reducing dependence on energy imports. If the industrialized countries expect cooperation, though, they should make available at minimal cost the most advanced energy-saving technology, especially for power plants, and help finance the purchase.

By far the most efficient and effective way to spur conservation is to raise the cost of fossil fuels. Current prices fail to reflect the very real environmental costs of pumping carbon dioxide into the air. The answer is a tax on CO_2 emissions—or a CO_2 user fee, if that is a more palatable term. The fee need not raise a country's overall tax burden; it could be offset by reductions in income taxes or other levies.

Imposing a CO_2 fee would not be as difficult as it sounds. It is easy to quantify how much CO_2 comes from burning a gallon of gasoline, a ton of coal or a cubic yard of natural gas. Most countries already have gasoline taxes; similar fees, set according to the amount of CO_2 produced, could be put on all fossil-fuel sources. At the same time, companies could be given credits against their CO_2 taxes if they planted trees to take some of the CO_2 out of the air.

A user fee would have benefits beyond forcing a cutback in CO_2 emissions. The fuels that generate carbon dioxide also generate other pollutants, like soot, along with nitrogen oxides and sulfur dioxide, the primary causes of acid rain. The CO_2 tax would be a powerful incentive for consumers to switch from high-CO_2 fuels, such as coal and oil, to power sources that produce less CO_2, notably natural gas. When burned, methane generates only half as much CO_2 as coal, for example, in producing the same amount of energy.



SMALL WONDER: Wind farms like this one in Livermore, Calif., slow global warming only a little, but every bit helps

Ultimately, though, the world must move away from fossil fuels for most of its energy needs. Said Berrien Moore, director of the Institute for the Study of the Earth, Oceans and Space at the University of New Hampshire: "Even if you cut emissions of CO_2 in half, the atmospheric concentration will keep going up. You're still adding CO_2 faster than you're withdrawing it, so the balance keeps rising."

Of all the known nonfossil energy sources, only two are far enough along in their development to be counted on: solar and nuclear, neither of which generates any greenhouse gases at all. Solar power is especially attractive. It produces no waste, and it is inexhaustible. Not all solar power comes directly from the sun: both wind and hydroelectric power are solar, since wind is created by the sun's uneven warming of the atmosphere and since the water that collects behind dams was originally rain, which in turn was water vapor evaporated by solar heating.

But wind and hydroelectric power can be generated at only a relatively few sites, and so governments should redouble financing for research to develop efficient, low-cost photovoltaic power. Photovoltaic cells, which produce electric current when bathed in sunlight, were briefly in vogue during the energy crises of the 1970s, and while public attention and Government funding have waned, research into the technology has continued. "The capital costs have come down from about $50 a peak watt to $5," said Speth. If they drop to $1, solar power will become competitive. That could happen without significant Government research support—but it will happen sooner with it.

Sometime early in the next century, solar enthusiasts hope to see vast tracts of photovoltaic collectors providing cheap electricity that can be transmitted over long distances. Alternatively, the electricity could be used to produce hydrogen from water. That could open up all sorts of possibilities. Cars, for example, could be redesigned to run on hydrogen, and that would produce a dramatic reduction in CO_2 emissions.

Nuclear power is more controversial; until recently the mere mention of it made environmentalists blanch. They had good reason, considering the accidents at Three Mile Island and Chernobyl, the problem of radioactive waste and the horror stories about U.S. weapons plants. But the greenhouse effect is forcing some antinuclear activists to rethink their position. "I was a strong opponent of the nuclear program in France," said Brice Lalonde, France's Environment Under Secretary and a former presidential candidate on the Ecologist Party ticket. "Now I am reassessing the whole thing." France gets more than 70% of its electricity from nuclear plants and has an impressive safety record.

Reactors in France, like all conventional reactors, depend for their safety in part on the skill and alertness of their operators. To minimize the risk of human error, engineers have developed designs for much safer types of nuclear reactors. But while these reactors, like experimental solar cells, show great promise, they are not yet economical enough to go on-line in significant numbers. It should therefore be a priority of governments to spend more money on research aimed at lowering the cost of safe nuclear and solar power and making them primary energy sources. Otherwise the global warming that results from overreliance on fossil fuels could [illegible] an increasingly uncertain and potentially bleak future. ■

The Good News: Osage, Iowa, Counts Kilowatts

The houses and businesses in Osage, a town of some 3,600 people in northern Iowa, seem just like buildings anywhere else in small-town America. Only a close look reveals the difference. Examine, for example, the new insulated roof on the local hospital that shaves utility bills 20%. Or venture into the basement of Steele's Super Valu grocery to see the wall that owner Everett Steele built around his cooling compressors to capture heat, which is then pumped into the store. Osage's model conservation program saved the town an estimated $1.2 million in energy costs in 1988 and made a modest but worthwhile contribution toward slowing down global warming.

The folks in Osage save energy the old-fashioned way: they plug leaky windows, insulate walls and ceilings, replace inefficient furnaces and wrap hot-water heaters in blanket insulation. Since 1974, the community has cut its natural-gas consumption some 45% and reduced its annual growth in electricity demand by more than half, to less than 3% a year.

Much of the town's energy saving can be traced to the zeal of Weston Birdsall, general manager of Osage Municipal Utilities. Looking back to 1972, when he took over the utility company, Birdsall recalls, "That's about the time OPEC reared its ugly head. We had to do something." Birdsall preached conservation door to door, offering to give every building a free thermogram, a test that pinpoints [illegible] where the most heat is escaping. More than half the town's property owners accepted the offer.

Birdsall's conservation campaign still flourishes long after similar efforts elsewhere have flagged. The utility recently decided to give customers $1[illegible] fluorescent light bulbs, which use far less energy than incandescent models. While Birdsall's strategies are based on simple, widely known techniques, few cities or towns apply the methods as diligently as Osage does. "Why aren't more people doing this?" Birdsall asks. Maybe more of them will if they come to realize that conserving energy not only saves money but also helps save the environment.

Nuclear Power Plots a Comeback

But safety comes first in new reactor designs

BY PHILIP ELMER-DEWITT

The primary purpose of the $3.6 billion nuclear plant that the U.S. Department of Energy wants to build in Idaho Falls, Idaho, is to help replenish America's dwindling supply of tritium, a vital component in atom bombs. But if approved by Congress, the Idaho facility could play an even more important role in the civilian use of nuclear power. For it is based on what proponents claim is a fail-safe technology, one that virtually eliminates the danger of a meltdown.

Nuclear plants have the potential of providing abundant supplies of electricity without spewing pollutants into the atmosphere. But the nuclear-power industry has failed to deliver on that promise, at least in the U.S. Even before the accident at Three Mile Island in 1979, the costs of making atomic power safe were spiraling out of control. Since that episode, the industry has been at a standstill.

What makes the failure all the more disturbing is that it was unnecessary. Engineers have the know-how to build reactors that are demonstrably safer than those now in operation. Moreover, that basic technology has been available for more than 20 years. It was largely ignored in favor of a technology—the water-cooled reactor—that had already been proved in nuclear submarines. But water-cooled reactors are particularly susceptible to the rapid loss of coolant, which led to the accidents at both Chernobyl and Three Mile Island.

All nuclear reactors work by splitting large atoms into smaller pieces, thus releasing heat. The challenge is to keep the core of nuclear fuel from overheating and melting into an uncontrollable mass that can breach containment walls and release radioactivity. One way to prevent a meltdown is to make sure the fuel is always surrounded with circulating coolant—ordinary water in most commercial reactors. To guard against mechanical failures that could interrupt the transfer of heat, most reactors employ multiple backup systems, a strategy known as "defense in depth."

The problem with defense in depth is that no matter how many layers of safety are built into a conventional reactor, it can never be 100% safe against a meltdown. At its Idaho plant, the Energy Department wants to try a different strategy. Rather than construct a giant atomic pile that requires the cooling of large quantities of concentrated fuel, designers propose to build a series of four small-scale, modular reactors that use fuel in such small quantities that their cores could not achieve meltdown temperatures under any circumstances. The fuel would be packed inside tiny heat-resistant ceramic spheres and cooled by inert helium gas. Then the whole apparatus would be buried belowground. Lawrence Lidsky, an M.I.T. professor of nuclear engineering, calls this an "inherently safe" approach: it relies on the laws of nature rather than human intervention, to prevent a major accident.

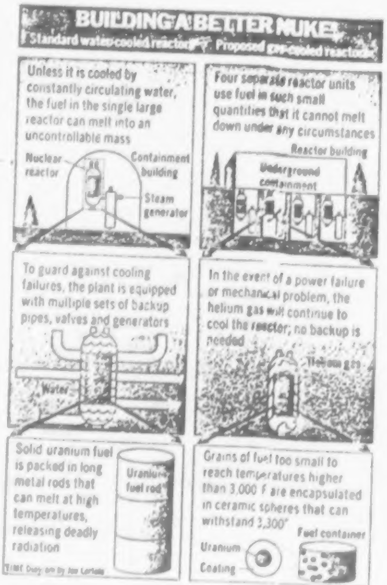
The main problem is that the modest electrical output of smaller units makes them less economical, at least initially. But proponents argue that inherently safe plants should prove more cost-effective in the long run. Not only would expensive safety systems no longer be needed, but the units could be built on an assembly line and put into operation one module at a time, enabling utility companies to match operating capacity with demand for power.

Critics are quick to point out that no nuclear reactor, either water-cooled or gas-cooled, is totally safe as long as it produces radioactive waste. The U.S. alone has generated thousands of metric tons of "hot" debris, including enough spent fuel to cover a football field to a height of three feet. Said Sir Crispin Tickell, British Permanent Representative to the United Nations: "The fact that every year there is waste being produced that will take the next three ice ages and beyond to become harmless is something that has deeply impressed the imagination."

There are ways to cope with the waste problem. The French have pioneered a process called vitrification that involves mixing radioactive wastes with molten glass. Over time, the hot mass should cool into a stable, if highly radioactive, solid that can be buried deep underground. The U.S. is also pursuing a strategy of deep burial, but the process has become ensnared in regional politics. Some sites that might have been suitable for an underground storage facility—the granite mountains of New Hampshire, for example—were quickly ruled out because of opposition from nearby residents. The one site now being considered, a remote mountain in southern Nevada, still faces formidable political hurdles.

It is a problem that can and must be solved. Third World countries do not have the technical or managerial expertise to deal with the complexities of nuclear power. They will be forced, at least for the foreseeable future, to rely primarily on environmentally harmful fossil fuels. That is going to put pressure on the developed world to produce increasing amounts of cheaper, safer nuclear power.

—*Reported by Glenn Garelick/Washington*


BUILDING A BETTER NUKE
Standard water-cooled reactor
Proposed gas-cooled reactor
Unless it is cooled by constantly circulating water, the fuel in the single large reactor can melt into an uncontrollable mass
Nuclear reactor
Containment building
Steam generator
Four separate reactor units use fuel in such small quantities that it cannot melt down under any circumstances
Reactor building
Underground containment
To guard against cooling failures, the plant is equipped with multiple sets of backup pipes, valves and generators
Water
In the event of a power failure or mechanical problem, the helium gas will continue to cool the reactor; no backup is needed
Helium gas
Solid uranium fuel is packed in long metal rods that can melt at high temperatures, releasing deadly radiation
Uranium fuel rod
Grains of fuel too small to reach temperatures higher than 3,000° F are encapsulated in ceramic spheres that can withstand 3,300°
Fuel container
Uranium
Coating
TIME Diagram by Joe Lertola

Deadly Danger In a Spray Can

Ozone-destroying CFCs should be banned

BY MICHAEL D. LEMONICK

When they were first synthesized in the late 1920s, chlorofluorocarbons (CFCs for short) seemed too good to be true. These remarkable chemicals, consisting of chlorine, fluorine and carbon atoms, are nontoxic and inert, meaning they do not combine easily with other substances. Because they vaporize at low temperatures, CFCs are perfect as coolants in refrigerators and propellant gases for spray cans. Since CFCs are good insulators, they are standard ingredients in plastic-foam materials like Styrofoam. Best of all, the most commonly used CFCs are simple, and therefore cheap, to manufacture.

There is only one problem. When they escape into the atmosphere, most CFCs are murder on the environment. Each CFC molecule is 20,000 times as efficient at trapping heat as is a molecule of CO_2. So CFCs increase the greenhouse effect far out of proportion to their concentration in the air.

A more immediate concern is that the chlorine released when CFC molecules break up destroys ozone molecules. The ozone layer, located in the stratosphere, between 10 and 30 miles up, is vital to the well being of plants and animals. Ozone molecules, which consist of three oxygen atoms, absorb most of the ultraviolet radiation that comes from the sun. And ultraviolet is extremely dangerous to life on earth.

The small amount that does get through to the earth's surface inflicts plenty of damage: besides causing sunburn, the rays have been linked to cataracts and weakened immune systems in humans and other animals. Ultraviolet light carries enough energy to damage DNA and thus disrupt the workings of cells, which is why excessive exposure to sunlight is thought to be the primary cause of some skin cancers.

When scientists first warned in the 1970s that CFCs could attack ozone, the U.S. responded by banning their use in spray cans. (Manufacturers switched to such environmentally benign substitutes as butane, the chemical burned in cigarette lighters.) But the rest of the world continued to use CFC-based aerosol cans, and overall CFC production kept growing. The threat became far clearer in 1985, when researchers reported a "hole" in the ozone layer over Antarctica. Although the size of the hole varies with the seasons and weather patterns, at times Antarctic ozone has been depleted by as much as 50% in some spots. As a result of this disturbing development, 24 nations, including the U.S. and the Soviet Union, met in Montreal two summers ago and agreed to cut back on CFCs. The so-called Montreal Protocol is designed to achieve a 35% net reduction in worldwide CFC production by 1999.

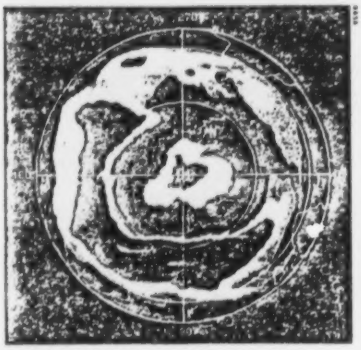
That is not good enough, however. The same stability that makes CFCs so safe in industrial use makes them extremely long-lived: some of the CFCs released today will still be in the atmosphere a century from now. Moreover, each atom of chlorine liberated from a CFC can break up as many as 100,000 molecules of ozone.

For that reason, governments should ensure the careful handling and recycling of the CFCs now in use. Said Senator Albert Gore of Tennessee: "Much of what reaches the atmosphere is not coming from industrial sources. It's things like sloppy handling of hamburger containers." When plastic-foam burger holders are broken, the CFCs trapped inside escape. Discarded refrigerators release CFCs as well, and, noted Gore, a significant part of the U.S. contribution to CFC emissions comes from "draining automobile air conditioners and leaving the stuff in pans where it boils off." Such release of CFCs could be prevented if consumers and businesses were offered cash incentives to return broken-down air conditioners and refrigerators to auto and appliance dealers. Then the units could be sent back to the manufacturers so that the CFCs could be reused.

While recycling will help, the only sure way to save the ozone is a complete ban on CFC manufacture, which should be phased out over the next five years. Fortunately, as the Montreal Protocol demonstrates, banning CFCs will be far simpler than reducing other dangerous gases. "The CFC producers are a small club of countries," said Brice Lalonde, France's Environment Secretary. But a ban could admittedly be economically disruptive to the entire world: the annual market for CFCs is some $2.2 billion. The Soviet Union, which is a heavy user of CFCs, will have a particularly tough time phasing out the chemicals. "I agree with the ban in principle," said Vladimir Sakharov, a member of the Soviet State Committee for Environmental Protection, "but in practice it will be extremely difficult. Our economy is not as flexible as others."

To make the transition easier, chemical companies are working hard to find practical substitutes for CFCs. The most promising approach so far is to use CFC family members that are chemically altered to make them less dangerous to the environment. The chlorine-free substance HFC-134a, for example, is most likely to be used in refrigeration devices.

The major drawback to CFC substitutes is the high cost of making them. It may be that until better manufacturing techniques are developed, consumers will have to pay more for affected products. The prospect is not a pleasant one, but it is a small price to pay for curbing the greenhouse effect and saving the life-preserving ozone layer. ■



OZONE HOLE: In this computer-colored image, taken by satellite in October 1987, the black and pink colors over Antarctica show the areas of greatest depletion. The extent of the hole varies with weather patterns.

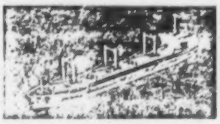
GLASS LANDSCAPE: Bottles piled at a dump in West Germany, where up to 15% of landfills are deemed dangerous

WASTE

A Stinking Mess

THE PROBLEM: Throwaway societies befoul their land and seas

BY JOHN LANGONE



The notorious *Pelicano* at sea

Like the journey of the spectral *Flying Dutchman*, the legendary ship condemned to ply the seas endlessly, the voyage of the freighter *Pelicano* seemed destined to last forever. For more than two years, it sailed around the world seeking a port that would accept its cargo. Permission was denied and for good reason: the *Pelicano's* hold was filled with 14,000 tons of toxic incinerator ash that had been loaded onto the ship in Philadelphia in September 1986. It was not until last October that the *Pelicano* brazenly dumped 4,000 lbs. of its unwanted cargo off a Haitian beach, then slipped back out to sea, trailing fresh reports that it was illegally deep-sixing the rest of its noxious cargo. A month later, off Singapore, its captain announced that he had unloaded the ash in a country he refused to name.

The long voyage of the *Pelicano* is a stark symbol of the environmental exploitation of poor countries by the rich. It also represents the single most irresponsible and reckless way to get rid of the growing mountains of refuse, much of it poisonous, that now bloat the world's landfills. Indiscriminate dumping of any kind—in a New Jersey swamp, on a Haitian beach or in the Indian Ocean—simply shifts potentially hazardous waste from one place to another. The practice only underscores the enormity of what has become an urgent global dilemma: how to reduce the gargantuan waste by-products of civilization without endangering human health or damaging the environment.

Scarcely a country on earth has been spared the scourge. From the festering industrial landfills of Bonn to the waste-choked sewage drains of Calcutta, the trashing goes on. A poisonous chemical soup, the product of coal mines and metal smelters, roils Polish waters in the Bay of Gdansk. Hong Kong, with 5.7 million people and 49,000 factories within its [illegible] sq. mi., dumps 1,000 tons of plastic a day—triple the amount thrown away in London. Stinking garbage and human excrement despoils Thailand's majestic River of Kings. Man's effluent is more than an assault on the senses. When common garbage is burned, it spews dangerous gases into the air. Dumped garbage and industrial waste can turn lethal when corrosive acids, long-lived organic materials and discarded metals leach out of landfills into groundwater supplies, contaminating drinking water and polluting farmland.

The U.S., with its affluence and industrial might, is by far the most profligate offender. Each year Americans throw away 16 billion disposable diapers, 1.6 billion pens, 2 billion razors and blades and 220 million tires. They discard enough aluminum to rebuild the entire U.S. commercial airline fleet every three months. And the country is still struggling to clean up the mess created by the indiscriminate dumping of toxic waste. Said David Rall, director of the National Institute of Environmental Health Sciences: "In the old days, waste was disposed of anywhere you wanted—an old lake, a back lot, a swamp."

HAZARDOUS DUTY: Cleaning up toxic chemicals in New Jersey

How to handle all this waste? Many countries have made a start by locating and cleaning up acres of landfills and lagoons of liquid waste. But few nations have been able to formulate adequate strategies to control the volume of waste produced. Moreover, there are precious few methods of effective disposal, and each has its own drawbacks. As landfills reach capacity, new sites become scarcer and more expensive. Incinerators, burdensome investments for many communities, also have serious limitations: contaminant-laden ash residue itself requires a dump site. Rising consumer demands for more throwaway packaging add to the volume.

Few developing countries have regulations to control the output of hazardous waste, and even fewer have the technology or the trained personnel to dispose of it. Foreign contractors in many African or Asian countries still build plants without including costly waste-disposal systems. Where new technology is available, it is too often inappropriate. In Lagos, Nigeria, five new incinerator plants stand idle because they can only treat garbage containing less than 20% water; most of the city's garbage is 30% to 40% liquid.

Even in highly industrialized countries, there are formidable social obstacles to waste management: not-in-my-backyard resistance by many communities to new disposal sites and incinerators is all too common. In the U.S. 80% of solid waste is now dumped into 6,000 landfills. Their number is shrinking fast: in the past five years, 3,000 dumps have been closed; by 1993 some 2,000 more will be filled to the brim and shut. "We have a real capacity crunch coming up," said J. Winston Porter, an assistant administrator of the Environmental Protection Agency. In West Germany 35,000 to 50,000 landfill sites have been declared potentially dangerous because they may threaten vital groundwater supplies.

What can be done to prevent the world from wallowing in waste? Most important is to reduce trash at its source. At the consumer level, one option is to charge households a garbage-collection fee according to the amount of refuse they produce. Manufacturers too need more prodding. Higher fines, taxes and stricter enforcement might force offending industries to curb waste. Industry must also re-examine its production processes. Such an approach already has a successful track record. The Minnesota Mining and Manufacturing Co. has cut waste generation in half by using fewer toxic chemicals, separating out wastes that can be reused and substituting alternative raw materials for hazardous substances. 3M's savings last year: an astonishing $420 million. In the Netherlands, Duphar, a large chemical concern, adopted a new manufacturing process that decreased by 95% the amount of waste created in making a pesticide.

Recycling, of course, is perhaps the best-known way to reduce waste. Some countries do it better than others. Japan now

What Nations Should Do

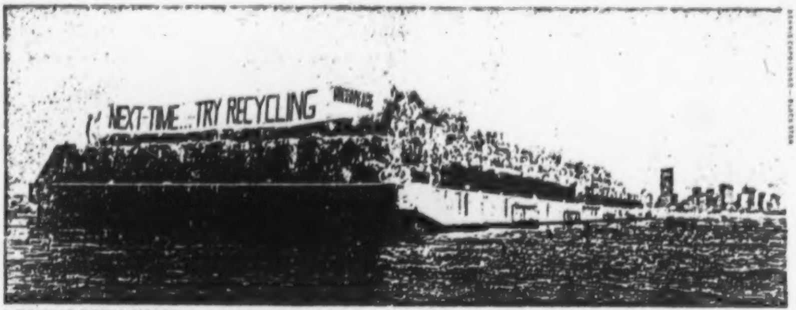
1. Raise the price of garbage collection and toxic-waste removal and the penalties for improper disposal as incentives for companies and households to curb the problem at the source. Households should be charged according to the amount of garbage they produce.

2. To encourage recycling, sharply increase the variety of containers that can be returned to stores or other collection points for cash. Raise the reward for returned items. Require households to sort garbage into recyclable and nonrecyclable items.

3. Increase funding for the testing of chemicals to determine their toxicity and cancer-causing potential.

4. Ban ocean dumping.

5. Ban the export of waste.



LOOKING FOR A HOME: Draped with a protest banner, an unwanted garbage barge floats off New York

recycles more than 50% of its trash, Western Europe around 30%. The U.S. does not fare nearly so well: only 10% of American garbage—or 16 million tons a year—is recycled, and only ten states have mandatory recycling laws.

Some experts believe local governments should hike cash refunds to people who return disposable items. Said Nicholas Robinson, who teaches environmental law at Pace University School of Law: "If we could persuade legislatures to increase the recycling price for a bottle from, say, a nickel to maybe a quarter or 50¢, then that bottle would be a very valuable commodity."

But even with more efficient recycling, there will still be refuse. That means landfills and incinerators, however harmful their emissions, will be needed as part of well-managed waste-disposal systems for the foreseeable future. Where possible, landfills should be fitted with impermeable clay or synthetic liners to contain toxic materials, and with pumps to drain liquid waste for treatment and disposal elsewhere. Landfill waste can also be burned to generate electricity, but the U.S. uses only 6% of its rubbish to produce energy. By comparison, West Germany sends more than 30% of its unrecycled wastes to waste-to-energy facilities.

Knowledge of the whole refuse cycle is imperative. Of the more than 48,000 chemicals listed by the EPA, next to nothing is currently known about the toxic effects of almost 38,000. Fewer than 1,000 have been tested for acute effects, and only about 500 for their cancer-causing, reproductive or mutagenic effects. Funding must be increased for such research.

In the last analysis, the waste crisis is almost always most effectively attacked close to the source. There should be an international ban on the export of environmentally dangerous waste, especially to countries without the proven technology to dispose of it safely. In the past two years, some 3 million tons of hazardous waste have been transported from the U.S. and Western Europe on ships like the *Pelicano* to countries in Africa and Eastern Europe. Observed Saad M. Baba, third secretary in the Nigerian mission to the U.N.: "International dumping is the equivalent of declaring war on the people of a country." And if such wastes continue to proliferate, man will have all but declared war on the earth's environment—and thus, in the end, on his own richest heritage. ■

The Good News: Japan Gives Trash a Second Chance

With a barely audible whoosh, the large doors at the entrance open to a spacious glass-walled hall filled with lush green plants and the soothing sound of a trickling miniature waterfall. But the sleek municipal building in Machida, a bustling city in central Japan, is not a pristine botanical garden. The enticing entrance is merely the façade of a $65 million facility built to handle a dirty job: recycling the wastes of the city's 340,000 residents. "We collect roughly 100,000 tons of garbage a year and convert it back into valuable materials," says a smiling Kenichi Usui, a city waste-management official. He has good reason to be boastful. Japan, which is fast becoming the world's premier industrial power, is also in the forefront of effective waste management.

The country has made "waste not, want not" a national policy. Last year 50% of Japan's wastepaper, 55% of its glass bottles and 66% of its beverage and food cans were recycled. Much of the remaining trash was turned into fertilizers, fuel gases and recycled metals.

Behind the success are Japan's recycling technology and systematic garbage collection. The Machida plant can deal with almost any category of recyclable refuse: burnables, nonburnables, bottles, cans, durables such as furniture and refrigerators, and "harmfuls" like batteries. Depending on their category, the castoffs are filtered, burned, crushed or otherwise treated on their way to becoming reusable materials. Steel scrap is separated from other garbage by huge magnets. Much of the recycling is computer-controlled: only 45 people work in shifts to run the round-the-clock operation.

Prudent waste management would not be possible without the disciplined cooperation of the Japanese people. Before putting out their garbage, they religiously follow such requirements as separating bottles from cans and burnables like paper from nonburnables such as glass and hard plastic. People who want quick disposal of old refrigerators or TV sets need only make a phone call to the sanitation department for a special pickup. Observes Yumimaru Nakada, a senior official in Tokyo's public sanitation bureau: "Living in a crowded situation, the Japanese have come to learn that garbage recycling is no laughing matter."

And it certainly pays to recycle. From 100,000 tons of typical Japanese garbage comes enough wood pulp to make a roll of toilet paper that would wrap around the earth ten times.

CRUSHING NUMBERS: Cairo's crowds herald a projection that Egypt's population will nearly double, to 103 million, by 2020

OVERPOPULATION

Too Many Mouths

THE PROBLEM: Swarms of people are running out of food and space

BY ANASTASIA TOUFEXIS

Close to the Zócalo, Mexico City's great central square, lies the barrio of Morelos, a vast warren of dusty, potholed streets and narrow entryways. The passages lead to a gloomy world. On each side of a roofless patio is a ten-room jumble. Each room holds a family; each family averages five people. The only bathrooms—two to serve 100 people—are located at the back of the patio. The odor of grease and sewage permeates the air. Flies buzz relentlessly. The people who live here are considered lucky.

In the shantytowns on Mexico City's outskirts, tens of thousands of people shelter in huts made of cardboard with aluminum roofs. There is no running water and no sanitation. The stench is overpowering; garbage and human waste heap up in piles. Rats roam freely, like stray domestic animals.

To the more privileged, those scenes look like a science-fiction vision of civilization's breakdown, perhaps after a nuclear war. In fact, Mexico City has been described as the anteroom to an ecological Hiroshima. With 20 million residents—up from 9 million only 20 years ago—the Mexican capital is considered the most populous urban center on earth. Mexico City has been struck not by military weapons but by a population bomb.

Ultimately, no problem may be more threatening to the earth's environment than the proliferation of the human species. Today the planet holds more than 5 billion people. During the next century, world population will double, with 90% of that growth occurring in poorer, developing countries. African nations are expanding at the fastest rate. During the next 30 years, for example, the population of Kenya (annual growth rate: 4%) will jump from 23 million to 79 million; Nigeria's population (growth rate: 3%) will soar from 112 million to 274 million. Expansion is slower in Brazil, China, India and Indonesia, but in those countries the sheer size of existing populations translates into a huge increase in people.

In the poorest countries, growth rates are outstripping the national ability to provide the bare necessities—housing, fuel and food. Living trees are being chopped down for fuel, grasslands overgrazed by livestock, and croplands overplowed by desperate farmers. Horrifying images of starvation in northeastern Africa have captured world attention in the past decade. In India, according to government reports, 37% of the people cannot buy enough food to sustain themselves. Warned Shri B.B. Vohra, vice chairman of the Himachal Pradesh state land-use board in northern India: "We may be well on the way to producing a subhuman kind of race where people do not have enough energy to deal with their problems."

Prospects are so dire that some environmentalists urge the world to adopt the goal of cutting in half the earth's population growth rate during the next decade. "That means a call for a two-child family for the world as a whole," explained Lester Brown, president of the Worldwatch Institute. "In some countries there may be a need to set a goal of one child per family." That is a daunting challenge. During the past decade, many of the world's poor nations condemned the notion of family planning as an imperialist and racist scheme touted by the developed world. Yet today virtually all Third World countries are committed to limiting population growth.

But the effort needs to be speeded up. For starters, contraceptive information and devices should be available to every man or woman on earth who wants them. According to surveys by the United Nations and other organizations, fully half the 463 million married women in developing countries (excluding China) do not want more children. Yet many have little or no access to effective methods of birth control, such as the Pill and the intrauterine device (IUD). The World Bank estimates that making birth control readily available on a global basis would require that the $3 billion now spent annually on family-planning services be increased to $8 billion by the year 2000. The increase in funds could shave projected world population from 10 billion to 8 billion over the next 60 years. However, few modern contraceptive methods are ideally suited to the daily lives of Third World citizens. Two-thirds of the 60 million users of condoms, diaphragms and sponges live in the industrialized world. Men in developing countries frequently view condoms as a threat to their masculine image; women often find diaphragms impractical since clean water for washing the device is scarce.

The most popular form of population control in developing countries is sterilization. Some 98 million women and 35 million men around the world have resorted to that permanent solution. The other current mainstay is abortion, which the Worldwatch Institute's Brown called "a reflection of unmet family-planning needs." An estimated 28 million abortions are performed in Third World nations annually, and an additional 26 million in industrial countries. About half are illegal.

New forms of birth control are desperately needed, and a few are slowly appearing. Last year a French pharmaceutical firm introduced RU 486, a drug that helps induce a relatively safe miscarriage when given to a woman in the early stages of pregnancy. Another recent arrival is Norplant, steroid-filled capsules that are embedded in a woman's arm and deliver contraceptive protection for five years. The implant is approved for use in twelve countries, including China, Thailand and Indonesia.

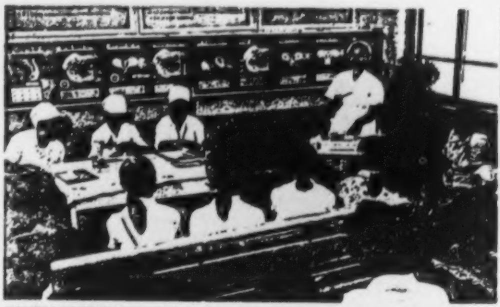
But progress is too slow. Additional spending on contraceptive research and development is badly needed. In 1972 global spending was estimated at $74 million annually, a paltry sum compared with many Third World military budgets. The funding in 1983 was just $57 million. One reason for the decrease was the Reagan Administration's antiabortion policy. U.S. contributions to international population-assistance programs declined 20% between 1985 and 1987, to about $230 million.

Bruce Wilcox, president of the Institute for Sustainable Development, an environmental-research organization based in Palo Alto, Calif., declared that solutions to the population challenge will demand "fundamental changes in society." Ingrained cultural attitudes that promote high birthrates will have to be challenged. Many families in poor agrarian societies, for example, see children as a source of labor and a hedge against poverty in old age. People need to be taught that with lower infant mortality, fewer offspring can provide the same measure of security. In some societies, numerous progeny are viewed as symbols of virility. In Kenya's Nyanza province, a man named Der[illegible] boasts that he has fathered 497 children.

Of all entrenched values, religion presents perhaps the greatest obstacle to population control. Roman Catholics have fought against national family-planning efforts in Mexico, Kenya and the Philippines, while Muslim fundamentalists have done the same in Iran, Egypt and Pakistan. Still, religious objections need not entirely thwart population planning. Where such resistance is encountered, vigorous campaigns should be mounted to promote natural birth-control techniques, including the rhythm method and fertility delay through breast feeding.

What Nations Should Do

1. Make birth-control information and devices available to every man and woman.
2. Expand educational and employment opportunities for women, which will stimulate their interest in family planning.
3. Where religious preferences inhibit the use of artificial contraception, provide education in natural birth-control techniques.
4. Increase funding for research and development of new methods of birth control that are easier to use or more acceptable in some cultures than current techniques.



CONTRACEPTION CONSENSUS: China has cut its growth rate in half through a program of classes—like this one in Beijing—and rewards and penalties

If there is a single key to population control in developing countries, experts agree, it lies in improving the social status of women. Third World women often have relatively few political or legal rights, and not many receive schooling that prepares them for roles outside the home. Said Robert Berg, president of the International Development Conference: "Expanding educational and employment opportunities for women is necessary for permanently addressing the population issue."

The effect of special programs for women has been demonstrated in Bangladesh. In 1975 the government launched a project in which associations of rural village women were provided with start-up loans for launching small businesses, such as making pottery, raising poultry and running grocery stores. About 123,000 women are currently enrolled in the cooperative. At weekly meetings, health-care and contraceptive information are distributed among members. An extraordinary 75% of the co-op members of childbearing age use contraceptives, while nationwide only 35% of married women practice birth control.

Ultimately, slowing the population juggernaut will depend on the ability of family-planning experts to create well-tailored programs for different societies and even for different segments of societies. But first, governments will have to raise public awareness and rally support for population control with a cohesive message about the dangers of rampant growth. India, one of the first countries to adopt a family-planning program, some 30 years ago, failed to forge a national will for the task, and the population is now growing at 2% a year.

In contrast, China has galvanized its people behind a huge population-planning effort. Still, its program demonstrates just how difficult—and risky—social tinkering can be. The nation launched its "one-family, one-child" policy in 1979. The aim: to contain population at 1.2 billion by the year 2000. In pursuit of that goal, local authorities have offered such incentives as a monthly stipend until the sole child turns 14 and better housing. Penalties for violating the policy have included dismissal from government jobs and fines of up to a year's wages for urban workers. China's effort has had some distressing consequences. Women have been coerced into having abortions, and there have been reports of female infanticide by parents determined that their one child should be a boy. Moreover, officials have acknowledged that exceptions to the one-child rule have been frequently condoned, especially in rural areas. In fact, only 19% of Chinese couples have one child. Beijing has announced that the nation will miss its target: the country's projected population in the year 2000 is 1.27 billion.

Yet for all its failings, China's effort has produced results. The population growth rate, once among the highest in the world, has been slashed in half, to 1.4%. And the Chinese are determined to reduce the rate still further. The same formidable task will face other developing countries as they confront the population bomb. But confront it they must. ■

The Good News: Thailand Controls a Baby Boom

He is a champion of condoms, a pusher of the Pill, a voice for vasectomies—and a major reason that the annual rate of Thailand's population growth was cut in half, from 3.2% to 1.6%, in just 15 years. And while he sometimes comes across as an energetic public relations man with a bagful of gimmicks, Mechai Viravaidya, 47, the engineer of Thailand's remarkable drive to curb its birthrate, regards population control as serious business.

In 1974 Mechai, a former government economist, launched a private nonprofit organization, now known as the Population and Community Development Association (P.D.A.), to foster family planning and distribute birth-control devices. With growing encouragement and financial support from the government, the Bangkok-based P.D.A. has made population control a national mission. Today some 70% of Thailand's couples practice family planning. Mechai estimates that without his program Thailand's population, currently 54 million, would have grown to 64 million.

He began by touting condoms—now commonly called mechais in Thailand. "Wherever there was a crowd, we would be there handing them out," says Mechai. "Movie theaters, traffic jams—we tried to turn every event into a family-planning session." With humor and showmanship, Mechai has judged condom-blowing contests and has shown how to use condoms as tourniquets. Each New Year's Eve, the P.D.A. gives traffic police boxes of prophylactics to distribute in a "cops and rubbers" program.

While continuing to hand out condoms, Mechai has helped couples move on to more sophisticated forms of contraception. He put birth-control "supermarkets" in bus terminals, offering Pills, IUDs and spermicidal foam as well as condoms. Mechai also opened vasectomy clinics across the country, including one in Bangkok's massage-parlor district. Each year on the King's birthday, the P.D.A. offers free vasectomies (normal price: $20).

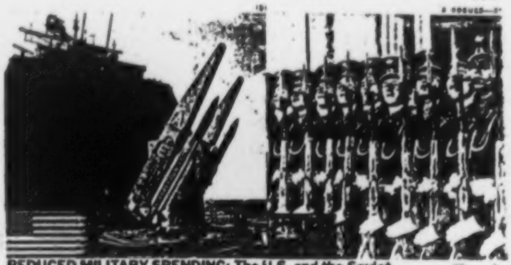
Champion of condoms

The campaign has brought about a profound change in the way Thais look at their families. The proof is in millions of people like Boonya Nuenmun, 36, a farmer in Korat province. Though his parents had nine children, Nuenmun says, "I've got two daughters, and that's enough already. I've been practicing birth control for years."

PLANET OF THE YEAR

A Global Bargain

Far more difficult than signing international treaties will be finding the money to make them work. The impoverished Third World countries, burdened with debt, cannot afford expensive environmental projects without outside help. Nor is the U.S. in a position to fund a new ecological Marshall Plan on its own. Here are the elements of a north-south deal that could pool the financial resources of the industrialized world and channel them into sustainable development plans for the poorer countries.



REDUCED MILITARY SPENDING: The U.S. and the Soviet Union could cut back their nuclear and conventional forces, shrinking their defense budgets and freeing funds for domestic and foreign environmental programs.

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Hands Across the Sea

Rich and poor, north and south, nations must get it together to face common disasters

BY THOMAS A. SANCTON

It is easy to draw up a plan of action for protecting the earth. But that plan will fail unless it is forged with international fellowship and carried out on a global scale. How much good can one country do by reducing carbon-dioxide emissions if another nation offsets that with an increased output of CO_2? How can one country keep its beaches clean if its neighbor down the coast dumps sewage or syringes into the sea? "On most environmental questions, the nation-state is obsolete," said Pace University's Nicholas Robinson. "We have to talk about multinational cooperation."

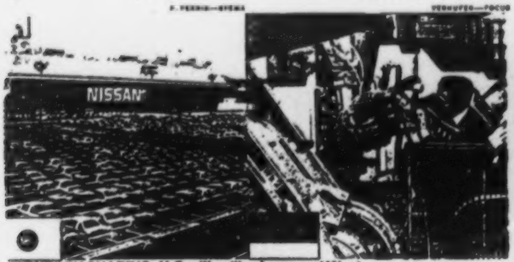
The first goal of that cooperative effort should be to gather the information needed to fashion effective policies. "We've got to get the earth in intensive care, to start to monitor the vital signs of the planet," said John Eddy of the University Corporation for Atmospheric Research in Boulder. This could be done by launching an International Earthwatch Program, possibly under the aegis of the United Nations, to coordinate multinational research projects and centralize essential data on the state of the world. Such an umbrella program could pool the results of hundreds of existing research efforts. A prime candidate for this program would be the Mission to Planet Earth, recommended by former astronaut Sally Ride, which would use NASA facilities to study the earth from space. In addition to improving knowledge of the earth's ills, an International Earthwatch Program could provide the basis for a widespread awareness-building campaign aimed at preparing public opinion for the sacrifices and life-style changes that will be necessary in the coming decades. Environmental education programs should be immediately introduced into schools and workplaces around the world, and government leaders should bring these issues into the heart of political debate.

But research and education are no substitutes for concrete action. The world community must move promptly toward comprehensive treaties to protect the air, soil and water. A framework for the effort exists within the U.N., which has already taken some important initiatives. In 1972 the U.N. organized the landmark Stockholm conference, which set up the United Nations Environment Program. It was under UNEP's sponsorship that 24 countries signed the 1987 Montreal Protocol, calling for a reduction in the output of ozone-destroying chlorofluorocarbons. There have also been proposals to enhance UNEP's role as a sort of intergovernmental superagency on environmental questions.

Paralleling the U.N.'s efforts, multilateral financial institutions have a crucial rôle to play. The World Bank, which lends money for Third World development projects, was long criticized by environmental groups for backing large, ecologically unsound programs—a cattle-raising scheme in Botswana that led to overgrazing, for example. During the past few years, however, the World Bank has been seeking to factor environmental concerns into its programs. One product of this new approach is an environmental action plan for Madagascar. The 20-year plan, which will be drawn up jointly with the World Wide Fund for Nature, aims at heightening public awareness of environmental issues, setting up and managing protected areas and encouraging sustainable development. Similar aims should also guide the lending policies of the International Monetary Fund, regional development banks and bilateral assistance programs.

Much of the current environmental crisis is rooted in, and exacerbated by, the widening gap between rich and poor nations. Industrialized countries contain only 23% of the world's population, yet they control 80% of the world's goods and are also responsible for the bulk of its pollution. On the other hand, it is the developing countries that are hardest hit by overpopulation, malnutrition and disease. As these nations struggle to catch up with the developed world, a vicious circle begins: their efforts at rapid industrialization poison their cities, while their attempts to boost agricultural production often result in the destruction of their forests and the depletion of their soils.

The greatest obstacle to economic and environmental improvements in the developing countries is their mammoth foreign debt. Collectively, the Third World owes $1.2 trillion to the



BURDEN SHARING: U.S. allies like Japan and West Germany would no longer be under pressure to raise military spending and could contribute to global security by increasing aid to the developing countries.

AID FOR THE THIRD WORLD: In exchange for foreign funds, the developing nations would agree to curb deforestation and adopt other responsible environmental policies.

banks and governments of industrialized countries. A new World Bank report estimates that in 1988 the developing countries made net payments of $43 billion to the industrial nations, up from $38 billion in 1987. How can the rich nations expect poor countries to launch environmental programs while struggling to pay off those crippling loans? Clearly, the Third World's debt payments will have to be lightened or postponed. The best way of doing that seems to be using debt forgiveness as leverage for winning environmental concessions.

One approach that has already been pursued successfully on a small scale is the so-called debt-for-nature swaps. Conceived by the Smithsonian Institution's Thomas Lovejoy in 1984, these innovative deals often involve the cooperation of governments, bankers and conservation groups. In a typical debt-for-nature swap earlier this year, the World Wildlife Fund, a nonprofit organization based in Washington, bought $1 million worth of Ecuadoran debt held by Bankers Trust at the discounted price of $354,500. The bank was happy to get the troublesome loan off its books, while the World Wildlife Fund gained the power to improve that country's environment. The fund accomplishes this by transferring the loan payments to Fundación Natura, a conservation group in Ecuador. Fundación Natura, in turn, uses the money to protect and maintain national parks and wildlife preserves.

However it is accomplished, a greater share of the world's capital will have to flow into developing countries. What they need, said Senator Albert Gore, is a new Marshall Plan for economic development and environmental preservation. But where will the money come from? For starters, the U.S. and the Soviet Union could reduce military spending in order to boost aid for environmental programs. Nobel laureate Murray Gell-Mann, a professor of theoretical physics at the California Institute of Technology, argued that the superpowers should redefine "global security" to include "the issues of population, environment and sustainable development." Yet the U.S., the world's largest debtor, can no longer supply the bulk of aid to the Third World. Nor can the economically strapped Soviet Union provide much financial help.

That leaves Japan, now the world's most financially powerful country, with a heavy responsibility for taking a leading role in bankrolling solutions to the environmental crisis. Japan has long shied away from assuming a major place in international affairs because of its militaristic adventures of the 1930s and '40s, but as Prime Minister Noboru Takeshita has made clear, his country realizes its international duty and is willing to shoulder it.

Japan's foreign aid appropriations of more than $10 billion in 1988 outstripped U.S. outlays, and Tokyo has increased its contributions to the World Bank and other environment-conscious lending institutions. The Takeshita government is willing to give more, but its efforts have ironically been hampered by the U.S., which is reluctant to give the Japanese a greater say in running these international groups. One solution might be to set up a new financial entity, an International Bank for Environmental Protection, in which the Japanese could have a major responsibility for both funding and management.

America, for its part, is at a turning point. The Reagan Administration, with its poor record on environmental issues, is coming to a close. President-elect Bush, who turned the pollution of Boston Harbor into a successful campaign issue, has an opportunity to show that he is serious about saving the planet—even after the election. He sent out an encouraging signal last week by naming veteran conservationist William Reilly to head the Environmental Protection Agency. Reilly, [illegible], president of the World Wildlife Fund, promised a "new and constructive course" on environmental problems. It is none too soon. —*Reported by Larry Hillenbrand/Tokyo and Richard Hornik/Washington*

Nobel for a Noble Cause

Physicists and chemists can earn the ultimate recognition: a Nobel Prize. Why not accord the same honor to environmental scientists? At the TIME conference, the proposal was backed by everyone from U.S. Senator Albert Gore to Vasili Peskov, a correspondent for the Moscow newspaper *Komsomolskaya Pravda*. Peskov suggested that the first environmental Nobel be given posthumously to Rachel Carson, whose 1962 book *Silent Spring* helped alert the world to the pollution threat.

Alfred Nobel's will set up five awards: physics, chemistry, medicine or physiology, literature and peace. But that limitation was overcome in 1968, when Sweden's Central Bank financed a separate economics prize in memory of Nobel.

What The U.S. Should Do

The U.S. has made significant strides in pollution control and energy conservation during the past 15 years, but the country remains the world's biggest user of natural resources and a major despoiler of the global environment. Because of the size of its economy, the U.S. consumes one-fourth of the world's energy each year. Yet, for a given amount of energy, the U.S. produces less than half as much economic output as Japan and West Germany. Meanwhile, the commitment to reduce pollution has flagged. Although the U.S. accounts for less than 5% of the global population, it generates 15% of the world's sulfur dioxide emissions and 25% of nitrogen oxides and carbon dioxide. Each American produces an average of 3½ lbs. of trash a day.

When energy was expensive, Americans treated it that way. Between 1973 and 1985, when the price of oil surged, U.S. per capita energy consumption fell 12% and the average amount of goods and services generated per person rose 17%. In the past few years, however, energy use has risen as the price has declined. Americans, who own more than 135 million cars, or about one-third of the world's total, have been driving more and have resumed their love affair with large gas-guzzling cars.

Because of its sheer size and influence, the U.S. must be in the vanguard of the effort to solve the earth's environmental crisis. Even before international bodies come up with global strategies, the U.S. can take many steps unilaterally and immediately.

1. Raise the Gasoline Tax

A gallon of unleaded gasoline, which costs roughly 95¢, is nearly a third cheaper now than it was eight years ago. When inflation is taken into account, the price decline is closer to 50%. Raising the federal gasoline tax by 50¢ per gal., from 9¢ to 59¢, over the next five years would renew drivers' interest in fuel conservation.

2. Toughen Auto Fuel-Efficiency Requirements

Federal regulations require that automakers produce fleets of cars with an average fuel efficiency of 26 m.p.g. The Government originally set a fuel-efficiency target of 27.5 m.p.g. for 1986, but the Reagan Administration allowed the car companies to postpone that goal. The new Administration should institute the 27.5 m.p.g. requirement and then gradually raise it to 45 m.p.g. by the year 2000.

3. Encourage Waste Recycling

The Federal Government should set national goals and standards for recycling programs but leave their implementation to state and local agencies. As an immediate first step, the President and Congress should require federal agencies to increase steadily their use of recycled paper products.

4. Promote Natural-Gas Usage

Far more abundant than anyone thought a decade ago, natural gas is the cleanest hydrocarbon fuel available. But in many cases, utilities that wish to switch from coal-fired power generation to gas-fired must go through a lengthy process to obtain a federal permit. Such regulations, which inhibit the increased use of natural gas, should be eased.

5. Encourage Debt-for-Nature Swaps

The U.S. opposes all government-subsidized debt relief for Third World countries. At a minimum, federal regulators should encourage U.S. banks to participate in programs that reduce debt in exchange for steps taken by debtor nations to protect tropical rain forests and other resources.

6. Support Family Planning

In 1984 the Reagan Administration cut off U.S. aid to the two major international family-planning organizations. Reason: the United Nations Fund for Population Activities and the International Planned Parenthood Federation have been accused of assisting some local population agencies that provide or pay for abortions. Unless the growth in the world population is slowed, it will be impossible to make serious progress on any environmental issue. The U.S. should immediately restore the aid it withdrew.

7. Ratify the Law of the Sea

The U.S. has never ratified the 1982 U.N. Convention on Law of the Sea, which sought to regulate mining and other commercial development. The Administration argues that the treaty interferes with private exploitation of the sea. That ideological issue should be put aside so that the U.S. can exercise global leadership and clear the way for international pacts aimed at protecting the atmosphere.

8. Make the Environment a Summit Issue

When the leaders of the major industrial nations gather next June in Paris for their 15th economic summit, George Bush should push to make environmental problems the No. 1 agenda item. Ronald Reagan's success at previous summits stemmed from his insistence on dealing with only one major topic. Should Bush take that approach in Paris, global environmental issues stand a better chance of getting the attention they deserve.

"What Is Wrong With Us?"

A Senator's impassioned call for action

If the steps needed to save the environment are well known and feasible, then why are they not taken? In a speech at the TIME *conference, Senator Albert Gore of Tennessee one of the most ardent environmentalists in Congress, explored this crucial question. Excerpts from his remarks:*

When I announced I was running for President, I said the greenhouse effect, the depletion of the ozone layer and the global ecological crisis will, by the end of this election year, be recognized as the most serious issue facing this country and the world. Three days later, a George Will column ridiculed the naiveté of a politician who could imagine that issues of this kind would be politically salable.

I guess he was partly right and partly wrong. I was right in that the issue has, during this year, attained enormous importance and new recognition. But he was right, since it didn't do me any good politically. There are still barriers to political action. Let me discuss five of them.

"Did God choose an appropriate technology when he gave human beings dominion over the earth? The jury is still out."

- Number one, there are areas of uncertainty about the greenhouse effect and the dire nature of the ecological crisis we face, which are seized upon as excuses for inaction. This is a psychological problem common to all humanity. If strong responses are needed and yet there is some residual uncertainty about whether you are going to have to make those responses, the natural psychological tendency is to magnify the uncertainty and say, "Well, maybe we won't really have to face up to it."

But the fact that we face an ecological crisis without any precedent in historic times is no longer a matter of any dispute worthy of recognition. And those who, for the purpose of maintaining balance in debate, take the contrarian view that there is significant uncertainty about whether it's real are hurting our ability to respond.

- The second barrier to political action is an unwillingness to believe that something so far outside the bounds of historical experience can, in fact, be occurring. To put it another way, this set of problems sounds like the plot of a bad science-fiction movie. People automatically assume it can't be real.

- The third political barrier is the assumption that it will be easier and more sensible to adapt to whatever climate change occurs than it will be to prevent the crisis. But the change could come so swiftly that adaptation will be all but impossible.

- The fourth barrier is the lack of widespread awareness among the peoples of the world about the nature of the problem. Most political leaders, let alone their public, are unaware of what is happening and how severe it is. That must be changed.

- The fifth barrier to political action is the knowledge that many of the ultimate solutions are almost unimaginably difficult. And since they are harder than anything we have done before, and the efforts may all come to naught anyway, why mess with them? Why not conserve our energy and just not even try? That is a formidable barrier, not least because the solutions require international cooperation on a scale that is totally unprecedented in history.

Those five barriers must be overcome before the political system reacts. The role of leadership is critical in spreading awareness, in framing solutions, in offering a vision of the future we want to create, as well as a vision of the nightmare we wish to avoid.

There is an old science experiment in which a frog is put into a pan of water, and the water is slowly heated to the boiling point. The frog sits there and boils because its nervous system will not react to the gradual increase. But if you boil the water first and then put the frog in, it immediately jumps out.

We are at an environmental boiling point right now. Is the destruction of one football-field's worth of forest every second enough to make the frog react and jump out of the pan? What will it take? If, as in a science-fiction movie, we had a giant invader from space clomping across the rain forests of the world with football field-size feet—going boom, boom, boom every second—would we react? That's essentially what is going on right now.

We saw the two whales trapped in the Arctic ice, struggling for air, and the world responded. The U.S. and the Soviet Union cooperated. Yet we see 40,000 babies starving every day, and we don't react. What is wrong with us?

There used to be a debate in the '70s about appropriate technology. Now the question is: Did God choose an appropriate technology when he gave human beings dominion over the earth? The jury is still out. And the answer has to come in our lifetime from the political system.

There are precedents. We made human sacrifice, once commonplace, obsolete. We made slavery obsolete. These things, just like changes in weather patterns, took a long period of time. But now, just as climate changes are telescoped into a very short period of time, changes in human thinking of a magnitude comparable to the changes that brought about the abolition of slavery must take place in one generation.

We know how to solve the problem. It will be unimaginably difficult. The cooperation required will be unprecedented. But we know what to do. What is required is a change in thinking and a change in the equilibrium of the world's political system.

Right now the political equilibrium is characterized by short-term policies at the expense of long-term policies. It is characterized by actions to confer national advantage at the expense of actions designed to promote global advantage. It is characterized by preparations for war, ignorance and starvation.

Our challenge as political leaders is to come up with an agenda of solutions, which we are doing. But the larger challenge for all of us is to shift the world's political system into a new state of equilibrium, characterized by more cooperation, global agendas and a focus on the future. As General Omar Bradley said at the end of World War II, "It is time we steered by the stars and not by the lights of each passing ship." ■

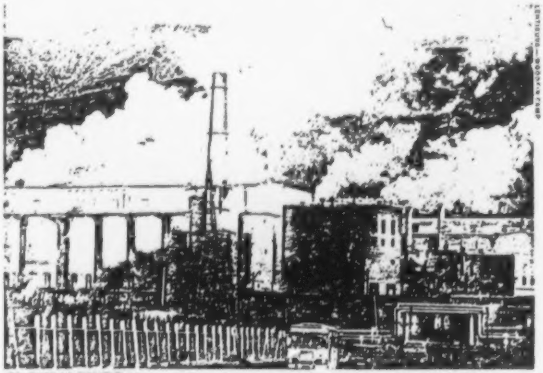
PLANET OF THE YEAR

The Greening of the U.S.S.R.

As his public cries out for a cleanup, Gorbachev fights a pall of pollution

BY DICK THOMPSON

The Soviet Union is an environmentalist's nightmare. The industrial city of Nizhni Tagil, some 700 miles east of Moscow, is sometimes wrapped in clouds of gaseous wastes so thick and toxic that drivers must turn on their headlights at noon and children walking home from school get skin rashes. Every year 700,000 tons of toxic substances are spewed into the city's air. Not only Nizhni Tagil but more than 100 other major cities, including Moscow, also have air-pollution levels ten times as high as the acceptable standards set by the Soviets.



CLOUDY SKIES: Gases billow from an apatite refinery on the Kola Peninsula

The land and water are not in any better shape. The riverbed of the Neva, which meanders beside the magnificent Hermitage in Leningrad, is covered with a thick layer of oil. Ill-advised dam construction and inappropriate irrigation projects have caused the level of the Aral Sea to drop 40 ft. It is possible that this body of water, the world's sixth largest sea, will not exist in 20 years. Siberia, [illegible] pristine, is laced with wastes from steel, chemical and coal industries. Worrisome numbers of dead sturgeon are floating atop the polluted Volga River, threatening the Soviets' prestigious caviar supply. Resorts along the Black Sea have banned swimming after the government's warning that the waters are contaminated with dysentery and typhoid germs.

For decades the Soviet people accepted the situation in silence. But *glasnost* has made them less afraid to speak out. Citizens worried about the environment are demonstrating by the thousands and contributing to political unrest in the Baltic States. Elsewhere, budding environmental groups have even sponsored candidates for city elections.

Amid the turmoil the Soviet government has finally begun to move. The Kremlin has reorganized a number of departments into the new State Committee for the Protection of the Environment, Goskompriroda, and given it an impressive range of powers. "In this restructuring," said Nicholas Robinson, a Pace University professor and an expert on the Soviet environment, "the Communist Party Central Committee has decided that, after disarmament, environmental protection is the No. 1 world issue." An aggressive cleanup program has already begun. Projects are being re-evaluated in light of their environmental impact. Fines have been levied on some polluters, and criminal proceedings have been started against others.

Internationally, the Soviets are pushing for stronger accords to protect the environment and are seeking ways to integrate their atmospheric-research efforts with those under way elsewhere. For the first time since World War II, the Soviet Union and the U.S. may have found a common enemy: global climate change. Said President Mikhail Gorbachev in his speech this month to the U.N. General Assembly: "International economic security is inconceivable unless related not only to disarmament but also to the elimination of the threat to the world's environment."

One sign of the Soviets' willingness to join international environmental efforts was their presence at the TIME conference in Boulder. Fyodor Morgun, the recently appointed head of Goskompriroda, made his first trip to the U.S. (and only his second journey outside the Soviet Union) to attend the meeting. And he was startlingly frank about the situation in his country. "We have started too late," Morgun told the group. "Our air is not up to the proper mark, our soil is polluted, and our forests are affected. Drastic measures were taken in the West 15 to 20 years ago to improve the environment. Now my country must get to work on this as well."

The Soviet environmental disaster has been a long time in the making. Beginning in the days of Stalin, ecological concerns were shunted aside in the rush toward industrialization. *Valovaya produktsiya*, a phrase that translates into "gross output" and is abbreviated as *val*, was at the heart of the problem. Industry bureaucrats have long been evaluated—and rewarded—only in terms of gross output. Rivers were fouled and forests stripped in the rush to transform raw materials into material wealth. No premium was placed on efficiency, and no environmental concerns restrained *val*. Trucks in Siberia, for example, are still left running every hour of every day throughout the winter because the vehicles are very difficult to start in the cold, and diesel fuel is plentiful.

Nowhere are the consequences of unchecked industrialization more obvious than in Siberia's Lake Baikal basin. Nearly 30 years ago, Minlesbumprom (the Ministry of Timber, Pulp and Paper, and Wood Processing Industry) erected the Baikalsh pulp factory on the shores of this majestic body of crystal-clear water. The crescent-shaped lake holds 80% of the country's fresh water and 20% of the world's supply. Three-fourths of the lake's 2,500 fish and plant species, including the Baikal nerpa, a fresh-water seal, are unknown anywhere else in the world.

All that is under assault. Currently, the pulp factory produces 200,000 tons of cellulose fibers a year, and its effluent, discharged directed into the lake, has created a polluted zone 23 miles wide. Clouds of yellowish smoke belching from the factory's smokestacks have settled over 770 sq. mi. of Siberian wilderness and have killed an estimated 86,000 fir trees.

The environmental offenses at Baikal and elsewhere revived the deep relationship that the Soviets have with nature. "Please believe me," said Morgun, "the people have awakened." From Armenia to Zaporozhye, hundreds of thousands have taken to the streets to protest everything from air pollution to nuclear-power plants. In April 10,000 people demonstrated against the conditions in Nizhni Tagil. Protesters in Priozyorsk were successful in closing a major paper plant that had been dumping waste into Lake Ladoga, the source of drinking water for 6 million people. Many of the political demonstrations in the Baltic States are linked to the environment. Said Marshall Goldman, associate director of the Russian Research Center at Harvard University: "In almost every republic in which there is a movement for independence or the assertion of political rights, it has been led by an environmental movement."

"We have started too late. Our air is not up to the proper mark, our soil is polluted, and our forests are affected. Drastic measures were taken in the West 15 to 20 years ago to improve the environment. Now my country must get to work on this as well."

FYODOR MORGUN

Gorbachev, whose background is in agriculture, has shown a special concern for the environment from the beginning of his reign. Early on, he toured the country and took care to detour from the carefully prepared showcase routes to inspect firsthand the polluted rivers and devastated forests. Funds for environmental protection, about $24 billion this year, are projected to reach $46.4 billion annually in the first half of the 1990s. At the same time, Gorbachev's regime has cracked down on polluters. Around Lake Baikal, about two dozen violations of ecological standards have been referred to prosecutors. In Nizhni Tagil the government has closed ten factories for failing to control toxic emissions and has begun criminal investigations against more than ten other plants.

But the Soviet leader may face a potential conflict between his desire for a cleaner environment and his hopes of rapidly raising the living standards and consumption levels of his people. Without careful pollution control, boosting production will befoul the environment even more. And money that goes into antipollution equipment cannot be used for industrial expansion. In Boulder, Morgun emphasized that the Kremlin wanted to get around this dilemma by redirecting money from military spending into the civilian economy. That, he said, depended on continued progress in arms-control talks with the U.S.

From an international perspective, the most disturbing aspect of the Soviet economy is the enormous quantity of carbon dioxide it puts into the air. Because the machines in many Soviet factories are obsolete and inefficient, they consume an inordinate amount of energy, making the country one of the largest contributors to the greenhouse effect. The Soviets are aware of this problem and hope to solve it by importing technology designed to improve energy efficiency and pollution control. They hope that much of that technology will come from the U.S. Said Morgun: "We will go anyplace, over any mountain, over an ocean to get the technology. And if you offer some kind of technology, we will be glad to accept it. We would be most grateful."

That is a plea the U.S. should take seriously, by easing restrictions on the export of industrial technology to the Soviets. Unfortunately, the biggest barrier to such shipments is not export controls but the lack of hard currency. The U.S. cannot finance the Soviet drive to conserve energy and control pollution, but America should offer as much technical assistance as possible. The Soviets seem to be sincerely determined to clean up their act, and the U.S. should help out.

—Reported by Ann Blackman/Moscow and Richard Hornik/Washington

TROUBLED WATERS: The once majestic Aral Sea may be gone in 20 years; studying the dried-up bed

PLANET OF THE YEAR

Preparing for the Worst

If the sun turns killer and the well runs dry, how will humanity cope?

BY PHILIP ELMER-DEWITT

If the nations of the world take immediate action, the destruction of the global environment can be slowed substantially. But some irreversible damage is inevitable. Even if fossil-fuel emissions are cut drastically, the overall level of carbon dioxide in the atmosphere will still increase—along with the likelihood of some global warming. Even if toxic dumping is banned outright and that ban is strictly enforced, some lakes and aquifers will be tainted by poisons that have already been released. Even if global population growth could somehow be cut in half, there would still be more than 45 million new mouths to feed next year, putting further strain on a planet whose capacity to sustain life is already under stress.

Sooner or later the earth's human inhabitants, so used to adapting the environment to suit their needs, will be forced to adapt themselves to the environment's demands. When that day comes, how will societies respond? How well will the world cope with the long-term changes that are likely to be in store?

To help answer those questions, political scientist Michael Glantz of the National Center for Atmospheric Research has pioneered the use of a technique known as "forecasting by analogy" to predict the effects on society of future climatic change. In a series of case studies, Glantz and his colleagues analyzed the response of state and local governments to actual environmental events across the U.S., from a 12-ft. rise in the level of Utah's Great Salt Lake to the depletion of the aquifer that supplies groundwater to eight Great Plains states.

When Glantz's forecasting technique is applied to the rest of the world, two things become clear. One is that virtually every long-term environmental change is occurring in miniature somewhere on the planet, whether it is a regional warming trend in sub-Saharan Africa or the vanishing coastline in Louisiana. The other is that Homo sapiens is an immensely resourceful species, with an impressive ability to accommodate sweeping change. In countries and regions hit by climatic upheavals, people have come up with a variety of solutions that are likely to have broad applicability to the global problems of tomorrow.

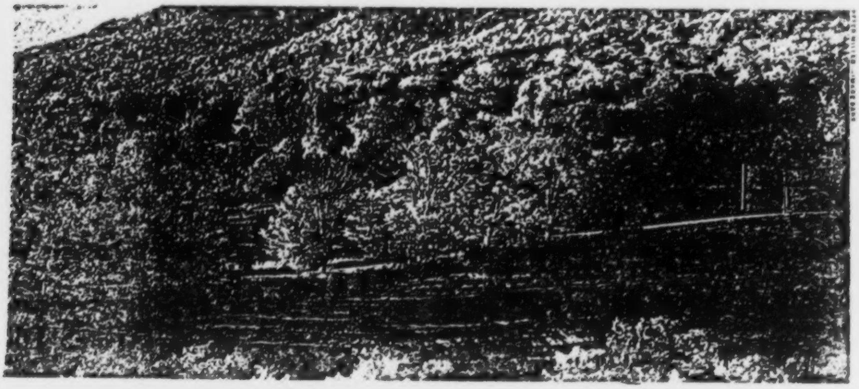
How would societies respond, for example, if the oceans were to rise by 3 ft. to 5 ft. over the next century, as some scientists have predicted? One option would be to construct levees and dikes. The Netherlands, after all, has flourished more than 12 ft. below sea level for hundreds of years. Its newest bulwark is a 5.6-mile dam made up of 131-ft. steel locks that remain open during normal conditions, to preserve the tidal flow that feeds the rich local sea life, but can be closed when rough weather threatens. Venice is beginning to put into place a 1.2-mile flexible seawall that would protect its treasured landmarks against Adriatic storms without doing ecological damage to the city's lagoon.

Shoring up cities such as New York, Los Angeles, Paris, London and Rio de Janeiro would require equally monumental measures. In the U.S. the Environmental Protection Agency estimates that the cost of protecting developed coastal areas could reach $111 billion. Southern Louisiana, which is losing land to the Gulf of Mexico at the alarming rate of one acre every 16 minutes, has already drawn up an ambitious mix of programs. In the biggest project, a $24 million pumping station would divert millions of gallons of silt-rich Mississippi River water into the coastline to help stop saltwater intrusion and to supply sediment that will build up the eroding land. At least one parish is considering plans for a backstop dike to give residents time to escape should the sea finally reach their doors.

Poorer countries have fewer options. Wracked by periodic floods, Bangladesh cannot simply evacuate the "chars"—bars of sand and silt in the Ganges Delta—where millions of people have set up camp. But the government has drawn up plans for a network of raised helipads and local flood shelters to facilitate the distribution of emergency aid if, as seems inevitable, disaster strikes again. Meanwhile, the country can only appeal to its Himalayan neighbors to do something about the root cause of the flooding: the deforestation of watersheds in India and Nepal that has turned seasonal monsoons into "unnatural disasters."

The problems of agriculture are likely to be critical in the next century, as growing populations, deteriorating soil conditions and changing climates put even more pressure on a badly strained food-supply system. In parts of sub-Saharan Africa, that system has broken down periodically over the past 20 years, resulting in the familiar TV images of children with swollen bellies and relief camps filled with hungry people.

What is not so well known is that hundreds of grass-roots organizations in Africa are taking action to cope with environmental change. Somalia has launched a vigorous antidesertification drive that includes a ban on cutting firewood. In Burkina Faso villagers have responded to steadily dwindling rainfall by building handmade dams and adapting primitive water-gathering techniques. Even so simple a trick as putting stones along the contour lines of a field to catch rainwater can make the difference between an adequate harvest and no harvest at all.



Necessity has spawned invention in marginal farmlands around the world. The Chinese, threatened by a desert that is spreading at the rate of 600 sq. mi. a year, are planting a "green Great Wall" of grasses, shrubs and trees 4,350 miles across their northern region. In Peru archaeologists have revived a pre-Columbian agricultural system that involves dividing fields into patterns of alternating canals and ridges. The canals ensure a steady supply of water, and the nitrogen-rich sediment that gathers on their floors provides fertilizer for the crops.

Perhaps no one is better prepared for hot, dry summers than Israel's farmers. The Israelis, using drip irrigation and other techniques, have made plants bloom on land that has been barren for millenniums. Portions of the arid Negev, an area once written off as largely uncultivable, today grow fruit, flowers and winter vegetables eagerly sought by European markets. Through a process known as "fertigation"—dripping precise quantities of water and nutrients at the base of individual plants—crops can be grown in almost any soil, even with brackish water.

Plant genetics is another option that needs to be energetically pursued. At the University of California at Riverside, plant physiologist Anthony Hall is working on a way to make cowpeas more tolerant to heat. Other scientists are using genetic engineering to transfer genes from bacteria that act like natural insecticides. But though they have tried, scientists have not yet been able to develop farm crops that are drought resistant. Says Hall: "You can't grow plants without water."

There are things people can do if the well runs dry. Several communities located near the sea have built desalinization plants. Denver, meanwhile, has pioneered the unsavory concept of turning sewer water into drinking water. In 1985 the city opened an experimental plant that produces 1 million gal. a day of high-quality H_2O from treated effluent.

Some scientists have suggested that the depletion of the ozone layer could be counteracted by a variety of Star Wars-like techniques. They include lofting frozen ozone "bullets" into the upper atmosphere and blasting apart ozone-depleting molecules in the air with huge terrestrial laser beams. But such grandiose schemes would be unreliable and could change weather patterns in unpredictable ways. In the end, it may be safer and cheaper, if inconvenient, to cope with ozone depletion by wearing wide-brimmed hats, sunglasses and sunscreen.

Man has always shown a great capacity for adjusting to change. Past generations have survived floods and ice ages, famines and world wars. But when dealing with the environment, there is a grave danger in relying on adaptation alone: societies could end up waiting too long. Many of the global processes under way, like the wholesale destruction of species, are irreversible. Others, like global climate changes caused by man, are so profound that if allowed to progress too far, they could prove to be overwhelming. Simple prudence suggests that taking forceful preventive action now—to save energy, to curb pollution, to slow population growth, to preserve the environment—will give humanity a much better chance of adapting to whatever comes in the future.

—Reported by J. Madeleine Nash/San Francisco

Magnitudes

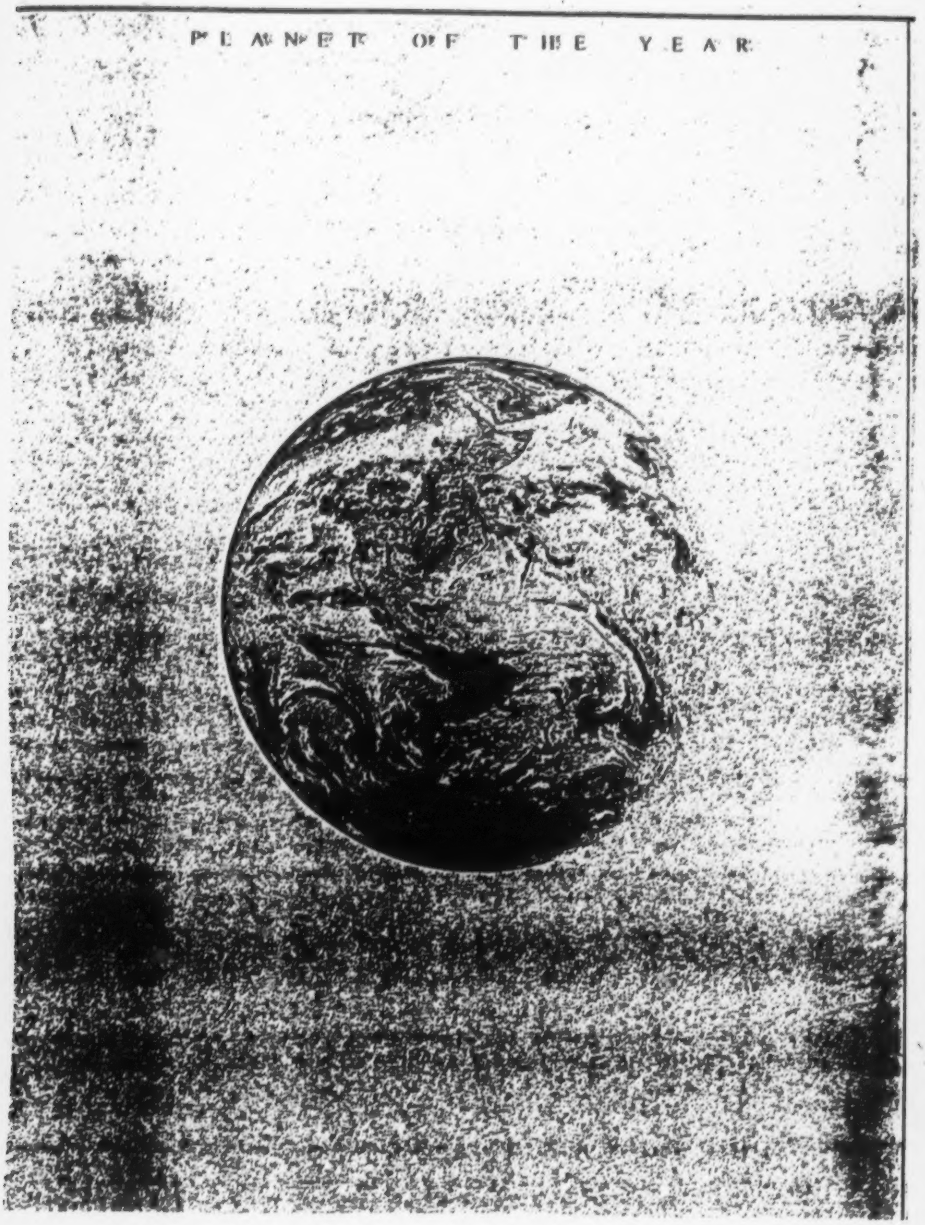
Earth's wrath at our assaults is slow to come
But relentless when it does. It has to do
With catastrophic change, and with the limit
At which one order more of magnitude
Will bring us to a qualitative change
And disasters drastically different
From those we daily have to know about.

As with the speed of light, where speed itself
Becomes a limit and an absolute;
As with the splitting of the atom
And a little later of the nucleus;
As with the millions rising into billions—
The piker's kind in terms of money, yes,
But a million in terms of time and space;
As the universe grew vast while the earth
Our habitat diminished to the size
Of a billiard ball, both relative
To the cosmos and to the numbers of ourselves,
The doubling numbers, the earth could accommodate

We stand now in the place and limit of time
Where hardest knowledge is turning into dream,
And nightmares still confined in sleeping dark
Seem on the point of bringing into day
The sweating panic that starts the sleeper up.
One or another nightmare may come true,
And what to do then? What in the world to do?

—Howard Nemerov

Nemerov is the poet laureate of the United States.


PLANET OF THE YEAR

Dr. **Blue**. I think it makes excellent reading. It certainly escalated the awareness, I think, on people's part of where we are going and what we have to do to change that course perhaps.

I think in 1989 you will see a consolidation of that view and perhaps a more full realization of how the Modular HGTR can contribute to the solutions. Not only do we have the potential for electricity generation, but in industrial process heat we can dramatically reduce oil imports. And, of course, ultimately I think you will see electricity making contributions to transportation through electric vehicles.

But we all recognize that in order for this to happen, nuclear energy must be acceptable. It must be accepted not grudgingly, but even enthusiastically. And how are we going to get to that point? Well, in my opinion there are obviously two parts to that equation. One is the waste, and I believe the Time Magazine article addressed that in a way that puts it in proper perspective.

There were two statistics there that particularly caught me. One was the incredible specter of forests of the world being consumed at a rate of one football field per second. That just is an incredible number.

By contrast, according to Time Magazine, the nuclear fuel waste accumulated over the last 30 years of generating power in this country with nuclear is only one football field three feet deep. One football field, 30 years, three feet deep compared to forests disappearing at a rate of one a second. I think with this kind of imagery, people can see that nuclear—it will put nuclear in perspective that people can understand.

With the substance of the kind of safety that we have, they will move toward this ability to accept it even enthusiastically as I said.

Now, the question is how do you get this safety, or what is the safety that is acceptable? We've heard about passive safety. Of course, we have that. We use the word "inherent safety." Some people have a problem with that term. But I think that we'd be happy just to talk about the fact that the reactor is not conducive to a meltdown.

But in the final analysis, there is another term that I think we can use and that's just "transparently" safe, so safe that anybody can understand it, so safe that you don't have to have a Ph.D in physics to explain the safety to you, so safe that it's as easy to image for people as the analogy of the football field and waste.

Truly I think we have that capability uniquely with this technology, thanks to the foresight of this Committee in funding it in a period when nobody wanted to see much of anything new happen in nuclear.

Well, of course, the funding has been going on, but unfortunately we're not quite there yet. It is essential that the commercial program continue and continue at a rate in my opinion of about $35 million for next year. Now, why must it be at that kind of level?

We have three distinct areas that must receive funding on the commercial side that don't relate to the NPR at all. One is the low-enriched core. That is an integral part of the commercial and it's different from the NPR. It must be funded if we're going to have commercial HGTRs.

We also have to do the commercial licensing which is unique to the commercial side of the program, and we also must do the unique elements of the preliminary design of the commercial program. If we don't fund that at least a rate of about $35 million this year, you will see the commercial program fall seriously behind.

What about the NPR? The NPR is a complement to the commercial program in every sense of the word because it will raise the funding from the annual rates of like $30 million that we've seen in the past to the hundreds of millions of dollars that we need to get the reactors up and going so everybody can see that they work and see that they work well and are potentially enormously profitable to the utilities that would want to use them.

So the two programs go well together. They must be funded separately, but the programs ultimately must and will be integrated by, I believe, a strong effort in the Department of Energy.

Finally, just quickly on the thermionic fuel element, some of the earlier witnesses talked about where space power is evolving. We certainly are pleased to see the recognition of the thermionic fuel element as being perhaps the most desirable because it eliminates launch problems. You don't have the problems of low orbit. It is truly a safe space power and it's extremely flexible, because you can go from 10 kilowatts to 200 times that amount, to 2 megawatts.

The original schedule called for completion of the test program, the demonstration program, by 1992. With the funding that's currently called for in the DOE schedule of $2.0 million from DOE, a companion to the $4.0 million from SDIO, that would simply extend the program out to '94. This power for space is needed, and it is truly needed yesterday. So I would urgently urge you to add another $3.0 million to the $2.0, make it $5.0, and we can give you the results hereafter for 1992.

Thank you, Madam Chairman.

[The prepared statement of Dr. Blue follows.]

STATEMENT FOR THE RECORD
FY90 DOE AUTHORIZATION
HIGH TEMPERATURE GAS-COOLED REACTOR
SPACE POWER

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON SPACE, SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

LINDEN S. BLUE
VICE CHAIRMAN
GENERAL ATOMICS

MARCH 1, 1989

Madame Chairman and Committee Members:

I am Linden S. Blue, Vice Chairman of the Board of General Atomics. I appreciate the opportunity to appear before this Subcommittee to testify on behalf of the Modular High Temperature Gas-Cooled Reactor (MHTGR). I wish to thank you for your continued support. Today I want to report on the progress and successes of our program.

The progress and successes to which I refer are the:

1. completion by the Nuclear Regulatory Commission (NRC) staff of the review of the MHTGR conceptual design and the pre-application licensing submittals and a subsequent favorable letter from the Advisory Committee on Reactor Safeguards (ACRS);
2. recommendation by the Department of Energy, after extensive evaluations, to build a four module, 538 MWe MHTGR facility at the Idaho National Engineering Laboratory as a part of the New Production Reactor (NPR) Program. Our team for the NPR includes Combustion Engineering, Stone and Webster, and Burns and Roe.
3. development by a private vendor team, composed of General Atomics, and others, of a preliminary prospectus for the initial commercial MHTGR facility on a fixed price, turnkey basis, followed by presentation of the prospectus to 10 major utility organizations;
4. growing recognition by the press, responsible environmentalists, and the public that the MHTGR is the prime candidate for the "improved safe nuclear power" which is an environmental imperative, given the concern over increasing atmospheric carbon (greenhouse effect), acid rain, and the limited availability of oil and natural gas.

In the light of these important achievements, I can see several different paths which could lead to commercial deployment of the MHTGR.

The path I recommend for FY'90 can lead to commercial deployment around the year 2000, but considers the political and financial realities of 1989. The MHTGR-NPR recommendation and associated FY'90 defense budget request verify the promise of the technology and will begin to supplement the civilian program. Realistically though, this program is not yet so sufficiently robust that we can allow it to replace the civilian program as the "flagship" for MHTGR development. We will, however, structure the civilian program to avoid duplication and to ensure that the two programs complement each other If the MHTGR-NPR were not included in the FY'90 budget request, the civilian program would need ~$60 million this year to meet the development, licensing, and deployment schedules which the vendors and the users have been supporting and which DOE's recently issued five-year contracts require. Considering the MHTGR-NPR defense project, I concur with my colleagues who are testifying today that $35 million will be necessary to nurture the momentum gained through our private initiative, and to support the activities and schedules at DOE, the national labs, and the industrial supporters.

As currently requested by the Administration, the MHTGR-NPR FY'90 budget would make a contribution to the reactor technology development and, potentially, a smaller contribution to ongoing safety analysis. The civilian program for FY'90 should therefore be structured to:

- Complete the technology and design for the low-enriched fuel cycle and magnetic bearings for the helium circulator.
- Continue the overall preliminary design effort required to support the ongoing civilian licensing process.
- Coordinate the two programs to maximize the commonality in the non-fuel components.

With this approach, the civilian MHTGR program will not only retain its momentum toward commercialization, but will also be positioned to benefit from the NPR program and to minimize the commercialization cost of the civilian MHTGR.

We are now seeing the first blush of success for the MHTGR; which would not have been possible without the vision and courage of this Subcommittee. The MHTGR-NPR may be an anvil upon which we forge the commercial MHTGR, but only if DOE, Congress, and private industry maintain their support and provide the other tools, effort, and resolve to hammer out the commercial product.

Civilian Program Accomplishments

During 1988, the NRC staff completed a lengthy review of the MHTGR and its safety characteristics. This review began in 1986 and focussed on the Preliminary Safety Information Document (PSID) which describes in detail the MHTGR conceptual design and its normal and accident performance. The conclusions reached by the staff and its consultants verify the accident analyses contained the PSID. They also generally acknowledge the technical adequacy of the passive safety philosophy embodied in the MHTGR and its ability to meet the advanced reactor safety criteria. The staff's results were presented to the ACRS, and the committee has issued a letter largely supportive of the staff conclusions. Unfortunately, formal release of the Safety Evaluation Report describing the staff's results has been delayed pending the Commission's resolution of the policy questions stemming from the fundamental differences between the MHTGR, the existing generation of reactors, and the DOE requirements for the new production reactors. I hope that this delay can be ended and the staff results released in the near future. Substantial further delay will endanger the current momentum of the program.

We are currently moving forward on the MHTGR preliminary design. This is the second major design phase, and its completion will coincide with the submittal of a Preliminary Safety Analysis Report. Under GA's short-term contract this year, 128 DOE milestones were completed furthering the nuclear island preliminary design.

Late in 1988, five-year contracts for the preliminary design and engineering of the balance of plant, nuclear island, and related systems were issued by DOE to Stone and Webster Engineering Corporation, Combustion Engineering, and General Atomics. These long-term contracts will provide increased continuity for the program. Continuity is extremely important if industry support of the program is to be increased.

The James Howden Company has been chosen as the subcontractor for the main helium circulator design. Having manufactured 116 gas-cooled reactor circulators, Howden brings significant circulator experience to the program The MHTGR circulator design will incorporate magnetic bearings from Magnetic Bearings Inc. There are currently nearly 400 machines operating worldwide with magnetic bearings and 10 percent of these are of comparable size or larger than the MHTGR circulator. We are confident that magnetic bearings will significantly increase MHTGR plant reliability while reducing maintenance and operating costs.

The 1988 completion of the design and fabrication of the Automatic Image Analyzer for performing automated quality control measurements on MHTGR coated fuel particles represented another important technical accomplishment for the program. This device allows large numbers of particles to be analyzed economically. Previously, human inspection of individual particles was necessary, making the inspection of large numbers of particles tedious and expensive. With the development of the Automatic Image Analyzer, it will be less costly to ensure that the high MHTGR fuel quality standards are being met during day to day fuel production.

Private Initiative for the First Commercial MHTGR

In late 1988 and early 1989, the MHTGR private initiative vendor team made presentations of a preliminary prospectus for an initial commercial MHTGR facility to ten of the country's major nuclear utilities. The fixed price, turnkey, commercial arrangement described in the prospectus would require the purchaser/owner to pay only the "competitive value" of a four-module, 538 MWe initial, commercial MHTGR facility. This competitive value (approximately $1.1 billion) will vary somewhat for different locations, but is defined as the capital price such that when combined with fuel costs, operating and maintenance (O&M) costs, and other costs, will result in total levelized power costs no higher than that projected for a new, similarly sized coal-fired facility. The vendor team also proposed long-term contracts for fuel fabrication and O&M, as well as plant level and fuel cycle warranties.

Such an offer is possible only if the government, the vendors, and the industry R&D agencies pool their efforts to support the technology development, design, licensing, and other first-of-a-kind (FOAK) costs to limit the purchaser risks. The scenario presented in the prospectus incorporates the preliminary results of discussions with senior DOE personnel and would require the government to:

- provide the funding for the development, design, licensing, and other FOAK costs; and

- provide a national policy indemnification or loan guarantee for the commercial investment in the facility.

With such assistance, the private sector should be willing and able to, as a minimum, match the government support which will be needed for the $1.8 billion total cost of the initial commercial facility.

The prospectus presentations by the MHTGR vendor team were well received by the utilities visited. Consumers Power is expected to enter into a site-specific joint feasibility study for an MHTGR facility with a scheduled start up around 2000. Several others indicated an interest in participating in similar studies as a major (100 to 200 MWe), but not lead, user. Utility interest was tampered by concerns about U.S. nuclear energy policy, unpredictable impacts of deregulation, nuclear licensing uncertainty, and the response of the financial community. Definition of an acceptable commercial arrangement for the first MHTGR power station will require more effort and work by all parties, but I do believe we have addressed the basic issues. Industry will do its part to deploy the MHTGR if government will complete the development and provide a stable regulatory and policy environment.

MHTGR- New Production Reactor Recommendation

The DOE recommendation to build four MHTGR modules at INEL is a real endorsement of the technology and the progress made toward the technological/societal goals set by this Committee in 1984. This recommendation was possible only because you and your colleagues maintained your support for the technology during the nearly ten years of evaluation by DOE, various independent panels, and advisory boards.

The purpose of the New Production Reactor is to produce tritium and special nuclear materials required for our national defense. The MHTGR-NPR selection will permit this mission to be accomplished reliably, efficiently, cost effectively, and with maximum safety. These characteristics, combined with the target capability which has been developed from the MHTGR fuel particle technology and the electric power production capability, allowed the MHTGR-NPR to be recognized as a very viable option. The commitment of the MHTGR-NPR vendor team of Combustion Engineering, Stone and Webster Engineering Corporation, Burns and Roe, and General Atomics to the project, allowed the MHTGR-NPR to be selected as an important part of the program.

In spite of the obvious advantages of the MHTGR-NPR and the prudence of the DOE recommendation of duality for both technology and location, pressures to minimize government expenditures remain a real threat to the INEL project. Since DOE also recommended a new heavy water production reactor at Savannah River, there will be a strong temptation to eliminate one of the projects to reduce the total expenditure. As a counter to such notions, I would note that the four-module MHTGR-NPR will produce not only tritium, but will generate electricity having a retail value of $5 billion to $10 billion over a nominal 30-year plant life. In addition, with proper coordination, the MHTGR-NPR will provide development, design, safety analysis, first-of-a-kind fabrication/construction and other technology transfer having a value of several hundred million dollars to the commercial MHTGR. With synergism of this magnitude, the commercialization of the MHTGR becomes even more feasible.

Recognition of the Need for the MHTGR

In the United States, there is growing recognition by the media, responsible environmental groups, and government leaders that we must reduce the environmental impact of fossil fuels and develop a new, safer form of nuclear power. Furthermore, there seems to be an emerging consensus that the MHTGR is a prime candidate for this new generation of nuclear power plants. The technical community has long recognized the need for nuclear power, but this broader acceptance only began to appear recently. A few years ago in the public press, one could only read about the high cost and grave risk associated with nuclear power. Today articles appear in publications such as the New York Times, Fortune, and Time extolling the advantages of and the need for advance reactors such as the MHTGR. This change has been catalyzed by hot, dry summers, dead lakes, unusually powerful hurricanes, an increasingly clear need for new generating capacity, and the development of new, safer reactor concepts. The MHTGR is the right technology at the right time to address these concerns.

At the same time that we are recognizing the undesirable environmental consequences of some long-standing energy sources, we are rapidly approaching the time when new generating capacity must be provided. In the early 1970s, as a result of the economic crisis which took place at that time, a sudden drop occurred in the rate of increase in electricity demand. Since generating capacity had already been under construction to meet the prior higher demand growth rate, a cushion of surplus capacity developed. Historically, a capacity margin of 20 percent is considered prudent, but by 1975, the margin exceeded 25 percent. This cushion has carried us through the 1980s, but it is now rapidly being eroded. Based on the growth rates of the past two years, the national capacity margin will drop below the critical 17 percent level in 1990 or 1991. In some areas of the country, generating capacity margins are undesirably small. Temporary power shortages were experienced in the Northeast this past year, despite significant power purchases from Canada. The demand for electricity in the United States rose by 5 percent in 1988. However, current construction of new generating capacity can only meet a 1 percent growth rate. Clearly, development of additional environmentally acceptable generating capacity such as the MHTGR must be given a high priority.

These problems are serious national issues, but they must not be viewed simply as national problems. They are global in nature. In the same way, the MHTGR should be viewed not just as a partial solution for the United States, but as an important contribution to the future world energy needs. While we in this country may be facing significant power shortages in the coming decade, such shortages are a fact of life in many nations. Developing nations will have to greatly increase their electrical generating capacities if they are to raise their standards of living above the poverty level. Other countries already produce over 70 percent of the CO_2 released each year. These emissions will increase dramatically as they increase their generating capability, unless they have access to a clean, simple, cost-effective power source such as the MHTGR. Exporting the MHTGR to other countries will help them meet their rapidly increasing electricity demands, it will reduce global CO_2 emissions, and it will improve our current world trade deficit. The U.S. trade balance will also benefit from plants built at home as imported oil and natural gas is replaced with MHTGR generated electricity.

Budget Recommendation

As I have noted previously, a stable funding program involving multiple year commitments is crucial to maintaining serious vendor, and particularly utility, interest in MHTGR deployment. The DOE five-year MHTGR design program and the MHTGR-NPR recommendation are two important steps toward a stable situation, but it remains to this Subcommittee and other members of Congress to fund this endeavor to the degree necessary to allow prudent private investment in the initial MHTGR commercial facility.

The civilian program will need a budget sufficient to maintain the momentum of the private initiative such that the first commercial facility can follow within one to two years of the scheduled 1998 start up of the MHTGR-NPR. The advanced reactor program activities should focus on the low-enriched fuel development,civilian licensing, and continuing the preliminary design. Sufficient funding for the NRC to continue their review is also important. These complementary activities for FY'90 will require $35 million to meet the objectives of the DOE contracts and the initial commercial facility deployment schedule.

It is particularly crucial that this Subcommittee continue its long-standing support to reinforce the commercial and international objectives of the MHTGR program. While the MHTGR-NPR will reduce the advanced reactor investment required for industrial deployment, it must not be allowed to become the singular focus for the technology. The MHTGR must not be allowed to be viewed only as a safe, efficient, publicly acceptable, environmentally benign production reactor. A substantial, continuing civilian program is important to wide scale deployment of this important, new, non-CO_2 producing energy source.

Thermionic Power Conversion Technology for Space Applications

The TFE Verification Program is a R&D program begun in 1986 by SDIO and DOE to demonstrate that thermionic fuel elements can meet lifetime and performance requirements for systems up to 5000 kW. Thermionic systems are very attractive for space applications because of their high survivability, low mass anD volume in orbit, potentially high reliability and easy scalability. This technology has been demonstrated to be applicable at the 10 kW level as recently shown by the USSR in their placing of two thermionic systems in orbit.

General Atomics is the prime contractor for the thermionic program; important subcontractors are Thermo Electron Technologies Corporation, Rasor Associates, and Space Power, Inc. Technical oversight is provided by Los Alamos, and the Westinghouse Hanford Company conducts the irradiation tests.

The TFE Verification Program was originally planned as a four-year program, but lower than expected budgets have extended the program to FY'92. The scope has been kept constant. The funds expended through FY'88 total about $19 million, 50 percent coming from SDIO and 50 percent from DOE

The funding situation for FY'89 is shown below. The current budget is less than the original plan (as of mid-1988) for both FY'89 and FY'90. The $2 million DOE budget for FY'90, which yields a program total of only $6 million, is particularly low, considering that fixed costs are between $2.5 million and $3.0 million (TRIGA reactor, fixed laboratory expenses, QA, minimal program management, etc.). The remaining funds, $3.0 to $3.5 million, will not permit the completion of key tests, and will cause the program to slip further into FY'93 or FY'94. Accordingly, it is recommended that the DOE budget for FY'90 be increased from $2 million to $5 million to permit completion of high priority tests in a cost effective manner.

	Plan as of mid-88 (Est.)	CURRENT BUDGET			RECOMMENDATION		
		DOE	SDIO	TOTAL	DOE	SDIO	TOTAL
FY89	9	3	4	7			
FY90	7	2	4	6	5	4	9
FY91	3						
FY92	1						

Test programs are underway in FFTF at Hanford, EBR-II in Idaho, and the TRIGA reactor at GA in San Diego. In addition, out-of-pile tests are being performed on insulators and thermionic converters. The results from the test programs have been very favorable.

Fueled emitter tests in the TRIGA reactor. Emitter distortion with reactor operation is a potential failure mechanism in thermionic cells. Nine fueled emitters were inserted in the TRIGA reactor in early 1985 and over 30,000 real time test hours have been accumulated. Emitter distortion as a result of fission product buildup within the emitter has been periodically measured by neutron radiography and compared with predictions. The results are generally favorable; the predictive capability is being verified.

Fueled emitter tests in EBR-II. Real time and accelerated tests of fueled emitters have also been underway in EBR-II since mid-1987. A second set of test specimens is being fabricated and will begin irradiation in August of this year. Postirradiation examination of some of the EBR-II specimens is underway, with completion on the first set of specimens scheduled for 1990.

Insulator development and testing. Insulator lifetime tests in a high neutron environment are a major part of the program. Fabrication development is focusing on several candidate insulator materials, and all are under test in out-of-pile accelerated tests. In-pile tests are underway in FFTF where two sets of test specimens have completed irradiation and are undergoing postirradiation examination. The fast neutron dose received was 200 percent of the peak design dose. A third and fourth set of specimens is scheduled to begin irradiation in 1990. Insulators have also been under test in the TRIGA reactor for over 30,000 hours.

The dimensional stability of the insulators irradiated in FFTF was good. The electrical performance after irradiation exceeded requirements for the alumina samples. Alumina appears to be the insulator best able to meet performance and lifetime requirements, with backup insulator materials being yttria and yttria-alumina-garnet.

Thermionic fuel elements (TFE). Several complete thermionic fuel elements will demonstrate the integrated performance of the thermionic components. A one-cell electricity producing TFE has been operating stably since September, 1988. Two more one-cell TFEs will begin test by mid-1989 and a three-cell TFE is scheduled for completion in FY-90. Additional multi-cell TFEs are scheduled for test in FY'90 and FY'91. Each incorporates improved design features that will be important for operational systems. The final experiment is a multi-cell TFE test in the FFTF.

Models and specifications. Performance and lifetime models are being developed for all TFE components. These are being documented in controlled reports which are reissued as improvements are. Manufacturing process specifications are also being issued. The program will establish a database that will provide the capability to fabricate thermionic converters for operational space power systems requiring a few kilowatts to 5000 kilowatts of electricity.

Madame Chairman, I appreciate this opportunity to describe the progress which our joint efforts have achieved this year. Although we cannot yet rest, we can note with some satisfaction the increasing interest in the promise of our program.

Mrs. Lloyd. Thank you very much for your outstanding statement.

Mr. Hoffman, we are delighted to have you with us today.

STATEMENT OF DAVID P. HOFFMAN, VICE PRESIDENT, NUCLEAR OPERATIONS, CONSUMERS POWER CO., REPRESENTING GAS COOLED REACTOR ASSOCIATES

Mr. Hoffman. Thank you, Madam Chairman, Committee Members.

I am here today representing the Gas Cooled Reactor Associates. I am Vice President for Nuclear Operation at Consumers Power Company. Different from most of the panelists who have been here before is that my career has been in the utility business, spent as a utility engineer in the power plants, and now responsible for two operating nuclear power plants.

I think another difference with the Gas Cooled Reactor Associates today is that it is the only group to date that is coming before the Subcommittee with a recommendation for funding not for itself, but for others. The funding that is in the R&D programs is not something that we are proposing or need for continuing on the Gas Cooled Reactor Associates in their efforts to continue to support the development and commercialization of a Modular High Temperature Gas Cooled Reactor.

A number of the speakers today have talked about the status of the nuclear industry in the United States, and I would just add a couple of things. From the utility perspective, there will be no new nuclear power generating stations built in this country until we have an improved licensing process and a nuclear plant design that is inherently safe not only to the technicians, but to the public.

Advanced reactors, I think, are going to have to play an important part of that as well as the licensing reform we see needed, again if we are going to have a viable nuclear program in the 21st century.

The options that are before us in the Advanced Reactor Program, whether it's the Advanced Light Water Reactor program or the Modular High Temperature Gas Cooled Reactor, I think is indeterminate at this time. Consumers Power Company, recently joining the Gas Cooled Reactor Associates, has done that for the purpose of considering and conducting a lead plant feasibility study in 1989.

What does that mean? That doesn't mean that we are out to order a new nuclear power plant. On the contrary, we are out to evaluate options. We feel at Consumers that we have an experienced, professional work force in the nuclear part of our organization. We've been operating the Big Rock Point plant for 28 years, quite well. We have not been operating our Palisades plant quite as well over the last 17 years but we think we are getting better at it.

We also have had to do a conversion of a nuclear power plant that we stopped construction of in 1984 and have been in the process, are in the process now of converting that to a combined cycle cogeneration facility. And I think that puts us in a unique position for future nuclear options.

The uniqueness is that we have had to go through some fairly unique funding activities to do the conversion of our Midland plant. We have the experience, with now over 25 years at our Big Rock Point plant, and we want to look at a way to utilize that experienced work force, the potential of various ownership options, various construction options, various options for energy use that we think the Modular High Temperature Gas Cooled Reactor is an excellent choice for.

About a year ago our chairman, in a speech here in Washington, used the term "idiot-proof design." That got a lot of negative feedback from workers, particularly in our organization, but I think the important point of that was that it's the image that we've been talking about. We have to have a design that, to the public, is fail-safe. It is passive, it is not going to be susceptible to the kinds of failures we've seen with today's designs.

The Modular HGTR, I believe, has a lot of the aspects that meet that criteria. Its fuel design, its core design and limited power size, modular, standardized, factory-constructed parts to it, fit a scenario that we believe in Consumers Power is the energy supply business of the future. And with uncertain load growths, with difficulties in funding multi-billion dollar projects, we feel the option is going to be at a much smaller capacity increment that the MHTGR allows us to look at.

We also believe there is some opportunity for economies of scale from staffing standpoint. With today's larger plants, we go very cyclic in our staffing needs in that we operate at a fairly constant level until we have scheduled outages or refuelings, and then we add 1,000 people to our sites for a short period of time, hopefully, and then reduce them back again. With the modular concept we believe it will give us some advantages to leveling off those people resource needs.

Again, I don't want to go into specifics of the technology that's in the testimony. Other speakers have already touched on a number of them. Again, the public perception, the idea that the MHTGR gives us an advancement that should lead and could lead to safety features that require no offsite protective actions for the public I think is a key part to it.

The issue of the modular construction and sizing will allow us, I think, to finance or put together an ownership option that we can meet not just from the utility, but from a combination of industry.

And it is our goal in doing this feasibility study that we evaluate it in the sense of use by the year 2000. That's when we see the next loads in our service territory that we have to address and have to begin addressing now.

As you have heard today, there are a number of research activities that must go forward for us to achieve that kind of a deployment of the Modular HGTR and we are recommending that the funding level for fiscal year 1990 be at $35 million for reasons already stated.

We also are supportive in the production reactor program and feel that there are important benefits from both programs going forward and things that will benefit the commercial program from that.

In conclusion, Madam Chairman, I want to thank you and the subcommittee members for their continued support in the advanced reactor programs. I think without that support, we are not going to be able to continue a nuclear option in the U.S. and I strongly encourage you to give consideration to the proposed funding for fiscal year 1990 that we've asked for. Thank you.

[The prepared statement of Mr. Hoffman follows:]

STATEMENT SUBMITTED FOR THE RECORD
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES

FY-90 DOE AUTHORIZATION FOR HIGH TEMPERATURE GAS-COOLED REACTOR PROGRAM

DAVID P. HOFFMAN
VICE PRESIDENT, NUCLEAR OPERATIONS FOR CONSUMERS POWER COMPANY
REPRESENTING GAS-COOLED REACTOR ASSOCIATES

Madam Chairman and Members of the Subcommittee, my name is David P. Hoffman and I am Vice President of Nuclear Operations for the Consumers Power Company. I am appearing here today on behalf of Gas-Cooled Reactor Associates (GCRA), the utility organization that supports the development and commercialization of the Modular High Temperature Gas-Cooled Reactor (MHTGR). Consumers Power has recently joined the GCRA Membership ranks and I am pleased to represent this overall utility support for the MHTGR Program to your Subcommittee.

Such utility support is based on the growing recognition of the need for a new generation of nuclear reactors to help meet future electricity demand without the undue environmental problems associated with the otherwise over-reliance on fossil fuels. In particular, the MHTGR offers quantum improvements in nuclear power technology that build very compatibly on the evolutionary improvements underway for the nearer-term Advanced LWRs. Such quantum improvements derive from the inherent material properties associated with ceramic coated fuel particles, graphite core structure and helium coolant. The adaptation of these inherent properties with design-specific features of low power density, low power rating and an annular core configuration collectively assure a passive, self limiting response for the full range of accidents considered for public health and safety protection. These characteristics result in enhanced safety margins without reliance on AC-powered safeguard systems and/or operator actions. The safety margins are sufficient to establish the technical basis for fulfilling the GCRA utility requirements of eliminating the need for offsite public evacuation and sheltering plans. As a result, the MHTGR should provide eased siting and licensing plus improved overall public acceptance. Other attendant benefits of the passive safety features include improved investment protection, simplified operation and maintenance activities plus improved reliability and availability.

The capability of adding small power increments, as low as 138 MWe, provide flexibility in meeting uncertain load growths plus improvements in the utility's overall system reliability. The modular nature of the design approach increases the extent of shop fabrication, which enhances standardization, quality assurance, learning, cost/schedule certainty and overall cost competitiveness. Further, the MHTGR is based on a low enriched uranium, once-through fuel cycle that does not raise nuclear proliferation issues. These overall features make the MHTGR well suited for the evolving business and regulatory environment within the U.S. and hence heighten the commercial prospects and payoff of the National investment in this technology. Further, the MHTGR is ideally suited for the export market, particularly the rapidly growing developing countries.

The MHTGR utilizes components and systems that have been proven in comparable applications. As a result, relatively modest resource demands are required to complete the design, licensing and technology development and verification effort required for Lead Plant deployment, design certification and commercialization. Past estimates of this overall effort are in the range of $1.8 billion ('87$), including a four reactor Lead Plant. Updated estimates developed in 1988 have been delayed but should be available by the end of March. The front-end development effort and the first-of-a-kind Lead Plant costs are in the range of $700 million ('87$), which is considered modest in the context of the overall National investment in other advanced reactors.

Our goal has been to complete the deployment of a Lead Plant by the turn of century such that the MHTGR will be an available option for expected generation capacity expansions and the replacement for retiring capacity. In order to meet this goal, a significant increase is necessary in the ongoing level of effort within the MHTGR Program, which is currently funded at approximately $20 million from DOE plus $4-5 million of private reactor support, primarily through GCRA and the prospective vendor participants. As you know, for FY 1990, DOE has proposed $15 million for the MHTGR Program. While this is a 100% increase over last year's proposed funding by DOE, we respectfully recommend a funding level in the range of $35 million. In our view, the MHTGR Program needs and deserves this level of DOE funding in FY 1990 to establish balanced technical resources for the design, licensing and technology development programs.

Key programmatic tasks to be supported by the proposed level of funding include: (1) increasing the pace of the ongoing preliminary design with particular emphasis on addressing resource deficient areas such as the reactor cavity cooling system, the plant control system and plant-level systems engineering; (2) advancing the Preliminary Standard Safety Analysis Report (PSSAR) on a schedule for submittal to the NRC in 1991 versus two years later if DOE's proposed funding level is sustained; (3) undertaking the much deferred technology development programs that must provide the validation of many of the design and licensing predictions. In particular, the fuel process development and qualification programs, the core physics validation program, the reactor cavity cooling system validation program and magnetic bearing circulator testing programs await adequate funding; (4) all together, fostering private sector support for a Lead Project initiative that will supply greater focus and purpose for the design, licensing and technology development programs.

In parallel to the civilian MHTGR Program, DOE has recommended that a four reactor MHTGR plant be deployed as a half-size New Production Reactor at the Idaho National Engineering Laboratory. The initial schedule projects startup of the initial module by 1998. The recommendation also calls for a concurrent full-size Heavy Water Reactor at the Savannah River Laboratory. The proposed budget for the MHTGR-NPR in FY 1990 is approximately $140 million which will cover ongoing target development and Environmental Impact Statement (EIS) work plus initiate development work specific to the MHTGR-NPR application. This proposed funding level highlights the subcritical resources being applied to the civilian MHTGR Program.

Recognizing the current funding uncertainties for the MHTGR-NPR Project, it is crucial that an aggressive civilian MHTGR Program be supported in FY 1990. In case Congress forecloses the MHTGR-NPR application this year, the civilian MHTGR Program must be capable of proceeding on a stand-alone basis. In case Congress defers the MHTGR-NPR construction commitment for a year, an aggressive civilian MHTGR Program in FY 1990 is still needed and will actually serve to advance the technical basis for such a NPR commitment. In case Congress commits to the MHTGR-NPR construction this year, an aggressive civilian Program is warranted to establish a balanced cooperative effort such that the civilian benefits from the MHTGR-NPR Project are realized.

GCRA has maintained support for the MHTGR-NPR application based on the prospects of stabilizing aggressive Government support for the front-end development and first-of-a-kind deployment costs. With a high degree of design and infrastructure commonality, a large fraction of this effort would be applicable to the civilian MHTGR Program. Crucial to realizing these benefits is the establishment of an aggressive civilian MHTGR Program and Lead Project that is closely coordinated with the MHTGR-NPR Project. Specific elements of this coordinated effort are addressed in an attached GCRA Statement that is offered for inclusion in the Congressional Record.

The need for such close cooperation is highlighted by the negative impact of the MHTGR-NPR on the NRC's review of the civilian MHTGR conceptual design. The issue stems from the inclusion of a underground "containment" chamber on the MHTGR-NPR that was added to meet DOE's initial specification, without consideration of a technical need. This difference in "containment" concept and the apparent lack of rationale is largely responsible for the delay of NRC's Safety Evaluation Report (SER) on the civilian MHTGR design, otherwise scheduled for the fall of 1988. Efforts continue to rationalize and/or resolve this discrepancy. In the interim, NRC is proceeding to issue the SER with a draft status and thereby allow access to the results of the overall review effort.

Independent of any NPR application, Congressional legislation is needed to establish a stable Government framework and funding commitment for completing the development, demonstration (if required) and certification of qualifying advanced reactors. Toward this end, several initiatives have been introduced and are under development.

In our view, such legislation would commit the very modest Government funding planned for the Advanced LWR Program on a 50/50 cost sharing basis with private sector sponsors. This Program is oriented toward design and early certification of several Advanced LWRs that apply evolutionary improvements to existing LWRs. Consistent with the long-standing position of the Advanced LWR Program, Government support is not required for the construction of any Advanced LWR Lead Plant.

For the MHTGR, a cost shared Lead Project is required to demonstrate the unique licensing aspects and support subsequent certification plus verify the performance, cost and vendor capability that is required for successful commercialization. Major Government funding support for the ongoing front-end design, licensing and technology development programs should continue until a Preliminary Design Approval and/or Construction Permit for the Lead Plant is obtained from the NRC. Subsequently, a consistent 50/50 cost sharing arrangement would apply on all future costs to build the Lead Plant and establish a design certification. A Government cap on the cost sharing would be based on half of the cost estimate established at the issuance of the Preliminary Design Approval and/or Construction Permit.

As other technologies enter preliminary design and Project considerations, this type of legislative model should apply equally well. Aspects of overall qualifying criteria, regulatory treatment, risk sharing and Project management also need to be addressed in the legislation.

Such legislation will be most important in engendering private sector participation and investment in advanced reactor deployment activities. With that prospect in view, Consumers Power Company is undertaking a MHTGR Lead Project Feasibility Study during 1989 centered around the use of utility personnel to operate the plant plus the consideration of several ownership arrangements, power use options and siting locations.

Consumers Power Company has a broad background with nuclear power to bring to the MHTGR Program. Our Big Rock Point plant, that we have been operating successfully for 28 years, is one of the early BWR plants built by GE. Our Palisades plant, that we have been operating for 18 years, was the first PWR plant sold by Combustion Engineering. We have recently completed a third party ownership arrangement for this plant which may serve as a worthy model for future nuclear plants, such as the MHTGR. Our Midland plant has been successfully converted from a nuclear cogeneration plant to a gas-fired cogeneration plant. We feel that this range of experience will be most valuable to the ongoing efforts within the MHTGR Program to establish a Lead Project.

Madame Chairman, you and this Subcommittee deserve much credit for the foresight of supporting the design approach embodied in the MHTGR that was initiated back in 1984/1985 and the steadfast support that has allowed the progress to date. We respectfully urge your continued support and careful consideration of our recommendations for the MHTGR Program in FY 1990 and beyond.

GCRA STATEMENT ON THE NEW PRODUCTION REACTOR AND THE CIVILIAN MHTGR PROGRAM

On August 3, 1988, the Department of Energy recommended the construction of a four-reactor Modular High Temperature Gas Cooled Reactor (MHTGR) facility at the Idaho National Engineering Laboratory (INEL) as part of a dual technology, dual site program to provide an adequate and secure supply of materials for the Nation's nuclear weapons requirements. The design of the MHTGR New Production Reactor (MHTGR-NPR) is derived from the reference four-reactor MHTGR design that is currently under development within the Department of Energy's advanced reactor development program. The Program is actively supported by utilities through Gas-Cooled Reactor Associates (GCRA).

GCRA has been supportive of the NPR application on the premise of a high degree of design and infrastructure commonality that provides an opportunity for mutual benefit from a cooperative development effort. The purpose of this statement is to outline the incentives for cooperation and to provide a utility/user perspective on important planning elements that require early attention.

INCENTIVES FOR COOPERATION

The incentives for cooperation between defense and civilian interests derive both from common elements in the respective designs, as well as from the common infrastructure that is required for deployment and support.

Of particular benefit to the defense interests is the extensive design, technology and licensing data base that has been developed through the civilian program. To the extent that common features are selected, the potential exists for reducing the design costs of the MHTGR-NPR as well as for sharing the remaining development costs, with attendant cost savings to both programs.

The development of an infrastructure for deployment and support is an important consideration for both the civilian and defense programs. Further, the infrastructure-related interests of the two programs are highly complementary. In the near-term, the NPR application provides a stable basis for government support of front-end technology and infrastructure development. The result will be a significant reduction of the related costs and risks that would otherwise be borne by the civilian program.

Conversely, the existence of a viable civilian MHTGR industry will be of considerable benefit to the operation of the MHTGR-NPR over its lifetime. This is because the cost of the supporting infrastructure will be spread over a larger base, thus reducing the cost of support services and, if required, follow-on deployments.

CONSIDERATIONS TO BE ADDRESSED IN NEAR-TERM PLANNING

Civilian Program Continuation

Of paramount importance to utilities/users is the maintenance of a distinct, viable civilian MHTGR Program that is responsive to utility/user requirements. Until a construction commitment is established for the MHTGR-NPR, the civilian MHTGR Program should be maintained in accordance with established plans. In particular, efforts should continue to establish a Lead Project for the civilian MHTGR Program. In the interim, coordinated development and deployment plans for both the MHTGR-NPR and the civilian Lead Project should be established.

Design Commonality

Based upon recent conceptual design and licensing activities, the principal functions, requirements and design features of the civilian MHTGR have been rigorously established by the Program participants and reviewed by the NRC and participating utilities. To minimize design and development costs, high priority should be given to an examination of current differences in the MHTGR-NPR (e.g.: containment system, reactor cavity cooling system, circulator bearings, etc.) to verify that these differences should remain.

Licensing Requirements and Coordination

Licensing has been a principal focus of the civilian MHTGR Program, with an ultimate objective being NRC certification of a reference nuclear island design. Close coordination between the civilian licensing program and the defense safety program is essential to minimize cross impacts and to achieve maximum benefit from related design verification analysis and testing. Development of a safety review/"licensing" equivalent plan for the MHTGR-NPR should be given early attention.

Vendor Development

The formation of a substantive vendor entity for the MHTGR plant (or at least the MHTGR nuclear island) plus a MHTGR fuel supplier is an obvious requirement for commercialization and an important long-term support factor for the NPR. To the extent possible, the procurement process and contractor arrangements for the NPR and the ongoing vendor development efforts within the civilian MHTGR Program should be mutually supportive.

Classification and Transferability of Design and Technology

The value of MHTGR-NPR design, development and deployment within the corresponding civilian program could be significantly impacted by the degree of security classification imposed on MHTGR-NPR design details and testing and operation results.

Consistent with National security requirements, the combined cost of development will be minimized when transferability of data important to the civilian application is enhanced. Near-term attention should be given to the interpretation of existing policy as it relates to the MHTGR, so that assured planning for civilian design and technology development can proceed.

International Cooperation and Foreign Market Potential

Cooperation has been established between the U.S. civilian MHTGR Program and corresponding foreign programs, notably in the Federal Republic of Germany, the United Kingdom and Japan. This cooperation involves technology development (e.g.: materials properties and safety related R&D), as well as industrial/ commercial arrangements. Where fully implemented, international cooperation provides significant savings to all parties involved. As international cooperation is expected to be limited to the civilian program, future opportunities for international cooperation should be considered in developing the overall development and deployment plans.

A further element for consideration is the excellent potential of the civilian MHTGR as a desirable export product. This prospect is enhanced by the civilian MHTGR's proliferation resistant LEU fuel cycle, small incremental size that enhances compatibility with small electrical grids and passive safety characteristics that place minimal demands on the operating infrastructure.

Communications and Management Coordination

The implementation of effective cooperation between the civilian and defense MHTGR Programs will require the establishment of effective communication and coordination channels among the participating parties. These channels should be established early in the planning process to obtain maximum benefit to both National defense and utility interests. A coordination forum, representing all principals, should be established to resolve policy, programmatic and technical issues between the NPR and civilian programs.

SUMMARY

In summary, the timely deployment of the MHTGR as a New Production Reactor offers a unique symbiotic opportunity that can benefit both National defense and utility interests. From the National defense viewpoint, deployment of the MHTGR-NPR will allow a significant financial offset to defense materials production cost, based upon the adaptability of an extensive data base and ongoing development program plus the power generation capability of the MHTGR. Longer-term savings will accrue as the civilian application potential of the MHTGR is realized. In the corresponding civilian program, deployment of the MHTGR-NPR will provide a stable government support for the common front-end development and deployment costs. The keys to realizing these mutual benefits are well coordinated and implemented development and deployment plans.

Mrs. LLOYD. Thank you very much, Mr. Hoffman.

PANEL 3 DISCUSSION

Mrs. LLOYD. Let's go back to the $35 million. That seems to be our magic number, and the Department of Energy said that they don't think this is necessary because the funding for the NPR will take care of some of these programs.

Mr. Blue, you stated that there are certain features in the civilian program that are inherent to this design that the reactor for military uses will not cover.

What would the $35 million be spent for?

Dr. BLUE. The engineering and design, continuation of the design. We have a lot of engineers on site in San Diego who are doing design work daily. Combustion has many as well, as does Stone Webster.

So it would be a matter of continuing the preliminary design, and only when you complete the design are you able to offer a serious package that the likes of Consumer Power can evaluate and say yes, this has the ingredients we want.

The other key factor, of course, is that the core is entirely different on the commercial. It's low-enriched, 19.9 percent enrichment versus 93 percent in the NPR. That is a very significant difference. It has to be separately designed and engineered.

And, of course, the work with the NRC that we have started to see the fruits of, and getting the SER out today was a major milestone, having their comments, having them begin to understand that they are dealing with a different animal here and it has some wonderful characteristics, that work has to continue because it is essential that as the design matures, the licensability matures along with it.

So we would continue these thrusts which are aimed at having something that fits within the kind of timetable that Mr. Hoffman is suggesting.

Mrs. LLOYD. I am glad that we could be the vehicle for NRC bringing this document.

Dr. BLUE. So are we.

Mrs. LLOYD. Mr. Blue, I understand that the Thermionic Fuel Evaluation program is underfunded, as you said, by about $3.0 million. Now, what would this increased funding be used for?

Dr. BLUE. Well, the problem we would have at the $2.0 million level is that and——

Mrs. LLOYD. That the program would just be stretched out further?

Dr. BLUE. Well, it would, but unfortunately most of the funds would be eaten up by the fixed costs of facilities that would go on operating. The additional $3.0 million would go to the specific sample work that they have to put in FFTF and EBR–II to get the analysis done to prove the technology.

So for that extra $3.0 million, bringing the whole program from $6.0 million to $9.0, you get an enormously greater work output instead of simply spending money on keeping existing facilities in operation.

So it's making the specimens. It's the labor for making the specimens and getting them proven. That's where the money will go.

Mrs. **Lloyd**. As both of you gentlemen know, there have been assertions that our nuclear space power systems just aren't safe. And some of this criticism is based on the Soviet reactors that have reentered the atmosphere.

Would you gentlemen comment on this?

Dr. **Blue**. The Soviets, of course, have just recently orbited two 10-kilowatt reactors of a thermionic design, thank goodness. The previous ones they have had were not, and we have had some of them come back to the earth with an undesirable effect.

The key to safety—and I would not represent myself as a final authority on the subject—but launch is the most perilous period, and if you have an isotope generator on launch, you potentially have a great deal of radiation. The TFE will be cold. It won't be activated until it is in nuclear safe orbit, and therefore you don't have the risk on launch of the radiation. Once it's out in distant orbit, you are okay also.

The Soviets have been inclined to orbit their reactors at a low earth orbit which is susceptible to coming back into the atmosphere and that is something that ought to be meticulously avoided.

Mrs. **Lloyd**. Mr. Hoffman, are there any other comments you would like to make?

Mr. **Hoffman**. No, Madam Chairman. Thank you.

Mrs. **Lloyd**. Thanks to both of you for being with us.

Mr. Morrison?

Mr. **Morrison**. Gentlemen, I am interested in the level of nuclear waste generated by the HTGR type reactor compared to other reactors in volume and radioactivity. I would appreciate knowing that.

Dr. **Blue**. It is comparable to light water. You have a little bit greater thermal efficiency, as you know, but you use a little bit more fuel. So the high-level radioactive waste is comparable to Light Water Reactors. It is substantially better in low-level waste because we don't have water coolant to be involved with.

In the Fort St. Vrain reactor, one of the things we like to point to, and I can't say that there are many things that we like to point to with that reactor, is the fact that the worker dose per megawatt of power produced was about 1/100 of the average dose of a Light Water Reactor.

So the waste situation on low level is considerably better. On high level it's about the same.

Mr. **Morrison**. I notice that the plans under NPR are to build four modular units.

Dr. **Blue**. Correct.

Mr. **Morrison**. And that produces half the goal quantity of tritium?

Dr. **Blue**. That's correct.

Mr. **Morrison**. I noted that in both your testimonies you indicated that, and that may be sort of an expensive pill to swallow. Those of us interested in energy production, of course, can hope that we can use the defense programs to help augment the limited dollars we have. But that will be the wrestling match, and I want to assure you of the interest of this Subcommittee in the High Temperature Gas Reactor concepts, whether in fact it's used for military purposes or not.

Dr. **Blue**. We appreciate that. Of course, when you figure the cost, you must remember that we are getting back some very valuable electricity.

Mr. **Morrison**. Yes, but we have another option that does the same thing.

Dr. **Blue**. I'm sure you are well aware of that one.

Mr. **Morrison**. Thank you very much, Madam Chairman.

Mrs. **Lloyd**. Thank you, Mr. Morrison. Thank you, gentlemen, for being with us today.

Oh, pardon me. Mr. Schiff, I didn't mean to overlook you.

Mr. **Schiff**. I have no questions. Again, as a new Member of the Committee, I'm still just drinking all this in Madam Chair. Thank you.

Mrs. **Lloyd**. Thank you again.

Our last panel for today's session is composed of three members: Dr. Jerry Grey, the Director of Science and Technology Policy at the American Institute of Aeronautics and Astronautics will be the first to present testimony. This is Dr. Grey's first appearance before the Subcommittee. We welcome you.

Dr. **Grey**. Thank you, Madam Chairman.

Mrs. **Lloyd**. The second witness on the panel is Mr. Charles Schmidt who is the Vice President and General Manager of the Astro Space Division of General Electric Company. Charlie is a familiar face before our Subcommittee. We thank you for being back today, Charlie.

Mr. **Schmidt**. You're quite welcome.

Mrs. **Lloyd**. And finally we've asked Dr. Mike Korenko to return to the witness table. It is my understanding that you will not be providing additional testimony, but we've asked you to be present so we can get the benefit of your expertise on space and defense issues.

Gentlemen, your statements will be made a part of the record and we ask you to summarize them. Dr. Grey, you are our lead witness.

Panel 4

STATEMENT OF DR. JERRY GREY, DIRECTOR, SCIENCE AND TECHNOLOGY POLICY, AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

Dr. **Grey**. Thank you, Madam Chairman. Actually, I used to appear before this Subcommittee fairly regularly when Mr. McCormick was its chairman, but that was a long time ago.

Mrs. **Lloyd**. Well, we're glad you're back today.

Dr. **Grey**. Thank you.

I will summarize my statement and just hit the high points, I think.

Mrs. **Lloyd**. Very good. And your entire statement will be entered into the record.

Dr. **Grey**. Thank you, Madam Chairman.

Because space nuclear fission reactors have stimulated most of the debate on development issues in this field, my statement today will focus on them, although that emphasis should not in any way imply that isotope energy sources are less important or less useful, as Dr. Korenko so eloquently demonstrated earlier this afternoon.

Nuclear reactors are needed because somewhere in the 10 to 40 kilowatt electric range, radioisotope sources become impractical and solar photovoltaic arrays have high drag, limit spacecraft operations and/or maneuverability, and impose a substantial mass penalty in the form of batteries.

Solar thermal dynamic systems are similarly limited and, like photovoltaic arrays, are fragile due to their low mass per unit area. In my prepared statement, I've listed a menu of civil and military missions which require long-term availability of power beyond that which can be conveniently delivered by either solar or radioisotopic sources.

Although these missions represent logical extensions of current activities in space, both civil and military, none are yet approved or funded. Why then should we develop costly nuclear reactor systems to meet their power requirements?

And here lies the catch-22 that has stymied U.S. development of nuclear reactor space power systems. As this Subcommittee's Members well know, research, technology advancement, and development of such systems were pursued vigorously in the 1950s and 1960s but were terminated in 1973 due to this catch-22. That is, no missions were funded to use nuclear reactor power plants because the technology was not available, and technology development was not funded because there were no specific missions which demanded it.

Today there is one space nuclear reactor technology development program underway in the U.S.—the SP-100 project. For the U.S. it's the only game in town for long-term, compact space power generation beyond the power levels of solar and isotope systems.

In a recent AIAA assessment of strategic defense technologies, the workshop report stated—and I quote: "The present SP-100 Ground Engineering System program should be accelerated and an early flight test program committed and funded immediately in order to allow initiation of the necessary preparatory work."

Now, unfortunately, there appears to be some confusion over the nature of the current SP-100 development. The generic flight system design, as it is currently called, is intended only to establish the technology base for a subsequent flight design based generally on the results of the Ground Engineering System test. It is not optimized for flight conditions. Such a flight system design cannot be configured until the generic SP-100 technologies have been demonstrated.

Now, suppose we were to decide, as we did once before in 1973, that our civil and military space programs will simply have to make do without the benefit of space nuclear reactors. The consequences of such a decision are obvious. The U.S. would forego the expansion of many civil or military space activities and would instead settle for a severely constrained status quo.

The Soviets provide a good example. They cut the Gordian knot of my catch-22, if you will pardon the double metaphor, by developing technology in advance of specific mission needs in two areas: space reactors and space launch capability.

Soviet development of space nuclear reactor power systems started in the 1950s with the ancestors of the thermionic reactor power plants they announced in Albuquerque last January. Several of the SNAP reactor programs terminated by the U.S. would have surpassed these Soviet systems and could have provided a sound technical basis for meeting the requirements of the advanced missions listed in my statement a decade or two sooner. But budget pressures prevailed, regretfully, and we foreclosed on these opportunities.

In space transportation, whereas the U.S. elected to terminate expendable launch vehicle development a decade and a half ago, although the Saturn V represented a two-decade lead on the Soviets and the rest of the world, the steady Soviet development effort in space transportation eventually culminated in the Energiya-shuttle combination, a capability the U.S. will require years of expensive development to match.

And note that although the Soviets do not as yet appear to have any committed or funded missions for their Energiya booster, the capability it offers gives them the option to pursue a slate of opportunities that are simply not open to the U.S. because of our budget-drive decision.

Besides pressures, there are other motivations to limit or even terminate space reactor development. One is the possibility that the reactors might contaminate the environment, and the second is that if the nuclear power option were to be withdrawn, it would impede the development and deployment of strategic missile defense and antisatellite weapons, which to some would be a good approach.

The basis for the environmental argument is the concern raised by the Soviet Cosmos 954, 1402, and 1900 incidents, which sensationalist journalism has hyped with phrases like "Chernobyls in space" and a "rain of radioactive death from the sky." Such incidents are not credible in the U.S. program because of its intense attention to safety concerns.

And arguing that the lack of nuclear space reactors would eliminate strategic defense or antisatellite weaponry is entirely fallacious. Why not apply the same reasoning to space launch capability or high-speed data processing systems as well? Moreover, there are many alternatives for non-nuclear-powered ASATs and missile-defense weapons. If it is decided that space weapons should be eliminated, so be it, but simply banning nuclear reactors in space is not the way to do that. Besides, such a ban would have absolutely no effect on near-term space weapon deployment options.

Completion of the SP-100 Ground Engineering System test and the subsequent development of flight test hardware, as we have advocated, will not be cheap. But unless we accept the challenge to do so, we will foreclose on a whole array of prospective future opportunities, many of which will go a long way toward reaffirming both our national security and the U.S. role as a major world power through excellence in space development and exploration.

Thank you, Madam Chairman.

[The prepared statement of Dr. Grey follows:]

AIAA
American Institute of Aeronautics and Astronautics

STATEMENT TO

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES

ON

SPACE NUCLEAR POWER SYSTEMS

BY

DR. JERRY GREY, DIRECTOR
SCIENCE AND TECHNOLOGY POLICY

AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS
WASHINGTON, DC

MARCH 1, 1989

The American Institute of Aeronautics and Astronautics (AIAA) is the world's foremost aerospace professional society. Our 43,000 members are drawn from U.S. industry, academia, and government as well as many other nations. The AIAA Technical Committee on Aerospace Power Systems and other technical groups of the Institute have addressed the subject of space nuclear power in some depth during the past three decades, and I am pleased to have this opportunity to present our views to the Subcommittee.

Of the two nuclear sources for space nuclear power generation, radioisotopes and fission reactors, the latter have stimulated most of the debate on development issues. My statement today therefore focuses on reactors, although that emphasis should not in any way imply that isotope energy sources are less important or less useful.

The fundamental rationale for the use of nuclear reactor energy sources for long-term power generation in space is that at some power level requirement, which is generally accepted to be somewhere in the 10 to 40 kWe range, radioisotope sources become impractical due to the large amount of radioactive materials needed and the difficulty of extracting the heat they generate. Within that same power range, also, the area required by solar photovoltaic arrays imposes undue limitations on most spacecraft missions because of the arrays' high drag and their constraints on spacecraft operations and/or maneuverability, as well as the substantial mass penalty imposed by the need for batteries or other energy storage devices to provide power during eclipse periods. Solar thermal dynamic systems, too, although of smaller specific area than photovoltaic arrays due to their higher cycle efficiency, are similarly limited and, moreover, are currently at a very early stage of development. They also share with photovoltaic arrays the inherent fragility of all large-area, low-mass-per-unit-area structures and the consequent lack of survivability in the face of various forms of environmental hazards or adversarial action.

During the past decades a number of civil and military missions have been identified which require long-term availability of power, independent of eclipse periods, at levels that may be beyond those which can be conveniently delivered by either solar or radioisotope sources. A representative (not necessarily complete) list of such missions appears in Table 1 below.

TABLE 1: MISSIONS REQUIRING LONG-TERM HIGH-LEVEL ELECTRIC POWER

MILITARY

A. General-Purpose Missions

- o Orbit transfer vehicles (electrically propelled)
- o Surveillance
- o Bistatic radar for Air Defense Initiative
- o Space-based radar
- o Wideband communications
- o Blue-green laser communications

B. Strategic Defense System Missions

- o Space surveillance and tracking systems
- o Neutral particle beam discrimination and weapons platforms
- o Orbit transfer propulsion
- o Space-based lasers for:
    - (a) Antisatellite weapons
    - (b) Free-electron lasers
    - (c) Chemical lasers
- o Space mirror platforms for ground-based lasers
- o Space-based electromagnetic launchers

CIVIL

- o Manned planetary/lunar rovers
- o Unmanned scientific and utility rovers (mining machines and material transporters)
- o Space-based central-power depots
- o Planetary surface activities (sortie missions, scientific research, mining operations, refining processes, etc.)
- o Permanent lunar and Mars bases (large-scale mining and materials processing, etc.)
- o Orbit transfer (electrically propelled)

Although these missions represent logical extensions of current activities in space, both civil and military, none are as yet approved or funded. Why, then, should we develop costly nuclear reactor systems to meet their power requirements?

Here lies the Catch-22 that has stymied U.S development of nuclear reactor space power systems. As this Subcommittee's members well know, research, technology advancement, and development of such systems were pursued vigorously in the 1950s and 1960s but were terminated in 1973 due to this Catch-22; that is, no missions were funded to use nuclear reactor powerplants because the technology was not yet available, and technology development was not funded because there were no specific missions which demanded it.

Today there is only one space nuclear reactor technology development program under way in the U.S: the SP-100 project, slated for Ground Engineering System (GES) test in the early 1990s. As with virtually all space programs since Apollo, the SP-100 technologies and system configurations, which are intended to be scalable over the range of tens to hundreds kWe, were arrived at through a series of compromises between projected requirements, budgetary and schedule constraints, operational considerations, and essential concerns focused on safety and environmental impact. Nevertheless, SP-100 is for the U.S. "the only game in town," and represents the sole effort aimed at establishing U.S. capability in long-term, compact space power generation beyond the power levels of solar and isotope systems. Indeed, in a recent assessment of strategic defense technologies, an AIAA workshop report stated that "the present SP100 GES program should be accelerated and an early flight-test program committed and funded immediately, in order to allow initiation of the necessary preparatory work. Higher-efficiency Brayton or Rankine cycle conversion subsystem development programs should be implemented immediately, and Stirling-engine and thermionic research efforts should also be accelerated to enable an early decision on which power subsystem to pursue for flight qualification."

Unfortunately, there appears to be some confusion over the nature of the current SP-100 development effort; that is, the hardware currently being developed in the GES test program is thought by some to comprise a so-called Reference Flight System. That is not the case; the Generic Flight System design, as it is currently labeled, is intended only to establish the technology base for a subsequent flight-system design based generally on the results of the GES. It is not optimized for flight conditions. Such a flight system design cannot be configured until the generic SP-100 technologies have been tested and demonstrated.

Suppose we were to decide, as we did once before in 1973, that our civil and military space programs will simply have to "make do" without the benefit of space nuclear reactors. The consequences of such a decision are obvious: the U.S. would forego the creation of a capability that would allow us to expand our civil and military space activities, and would instead settle for a severely constrained "status quo". History provides us with two examples that illustrate the effects of such a decision: the present Soviet capabilities on space power and space transportation.

Soviet development of space nuclear power systems started in the 1950s with the relatively modest Romaschka reactor (a 500W thermoelectric system) and progressed to the much more capable Topaz (7-15 kWe using thermionic conversion), which is probably the immediate ancestor of the thermionic powerplants recently announced by the Soviets at Albuquerque last January. Several of the SNAP (Space Nuclear Auxiliary Power) reactor programs terminated by the U.S. would have surpassed the Soviet systems and could have provided a sound technical basis for meeting the requirements of the missions listed in Table 1 a decade or two sooner. But budget pressures prevailed, regretfully, and we foreclosed on these opportunities.

In space transportation, the budgetary constraints imposed on NASA's space shuttle development program drove the U.S. to formulate the disastrous policy of terminating expendable launch vehicle development. Hence, although the Saturn-V represented a 2-decade lead on the Soviets (and the rest of the world), the steady Soviet development effort in space transportation eventually culminated in the Energiya-shuttle combination, a capability the U.S will require years of expensive development to match. And although there do not as yet appear to be any committed or funded missions for Energiya, the capability it offers the Soviets gives them the option to pursue a slate of opportunities that are simply not open to the U.S. because of our budget-driven decision not to sustain a comparable heavy-lift expendable-vehicle capability.

Besides budget-driven pressures to limit or even terminate U.S space reactor development, some have espoused such an action for different reasons. There are two such motivations: the possibility that space power reactors might contaminate the environment through inadvertent reentry, and the argument that if the nuclear reactor power option were to be withdrawn it would impede the development and deployment of strategic missile defense weaponry and (by eliminating Soviet nuclear-powered RORSATs) dissipate the need for the U.S. to develop antisatellite weapons.

The basis for the environmental argument is the concern raised by the Soviet Cosmos 954, 1402, and 1900 incidents, which sensationalist journalism has "hyped" with phrases like "Chernobyls in space" and "a rain of radioactive death from the sky". Such incidents are not credible in the U.S. program because of its intense attention to safety concerns. And arguing that the lack of nuclear reactor capability would eliminate strategic defense or antisatellite weaponry is entirely fallacious; why not apply the same reasoning to space launch capability or high-speed data-processing systems as well? Moreover, there are many alternatives for non-nuclear-powered ASATs and missile-defense weapons that could be developed in the event of a nuclear reactor ban. If it is decided that space weapons should be eliminated, so be it, but simply banning nuclear reactors in space is not a credible route to that goal, and, besides, would have very little effect on near-term space-weapon deployment options.

Completion of the SP-100 GES and the subsequent development of flight-test hardware, as the AIAA assessment has advocated, will certainly not be cheap. But unless we accept the challenge to do so, we will foreclose on a whole array of prospective future opportunities, many of which will go a long way toward reaffirming both our national security and the U.S. role as a major world power through excellence in space development and exploration.

Thank you for this opportunity to present my views on space nuclear power development. I will be pleased to answer any questions you may have.

BIOGRAPHY BRIEF FOR DR. JERRY GREY

Dr. Jerry Grey received his Bachelor's degree in Mechanical Engineering and his Master's in Engineering Physics from Cornell University; his PhD in Aeronautics and Mathematics from the California Institute of Technology.

His early career included stints as full-time Instructor of Thermodynamics at Cornell, engine development engineer at Fairchild, Senior Engineer at Marquardt, and hypersonic aerodynamicist at the GALCIT 5-inch Hypersonic Wind Tunnel. He was a professor in Princeton University's Department of Aerospace and Mechanical Sciences for 15 years, where he taught courses in fluid mechanics, propulsion, and nuclear powerplants and served as Director of the Nuclear Propulsion Research Laboratory. He formed the Greyrad Corporation in 1959 and was its full-time President from 1967 to 1971; from 1976 to 1982 he was Adjunct Professor of Environmental Science at Long Island University. He was Publisher of Aerospace America from 1982 to 1987, and is now Director of Science and Technology Policy for the American Institute of Aeronautics and Astronautics, consultant to a number of government and commercial organizations, and a Director of the Applied Solar Energy Corporation.

Dr. Grey is the author of twenty books and almost three hundred technical papers in the fields of solar energy, space technology, aerospace policy, fluid dynamics, heat transfer, rocket and aircraft propulsion and power, plasma diagnostics, instrumentation, and the applications of technology. He has served as consultant to the U.S. Congress (as Chairman of the Office of Technology Assessment's Solar Advisory Panel), the United Nations (as Deputy Secretary-General of the Second UN Conference on the Exploration and Peaceful Uses of Outer Space, 1982), NASA, the Department of Energy, and the U.S. Air Force, as well as over twenty industrial organizations and laboratories. He was Vice President, Publications of the AIAA for five years, Chairman of the Coordinating Committee on Energy of the American Association of Engineering Societies, and President of the International Astronautical Federation. He is currently a member of the Department of Transportation's Commercial Space Transportation Advisory Committee, a Director of the Scientists Institute for Public Information, a Fellow of the Explorer's club, and a member of the Office of Technology Assessment's Space Transportation Advisory Panel.

Dr. Grey is listed in Who's Who in America, Who's Who in Aviation & Aerospace, Engineers of Distinction, Contemporary Authors, American Men of Science, Men of Distinction, National Register of Prominent Americans, Who's Who in Technology Today, International Who's Who in Energy & Nuclear Sciences, The Writer's Dictionary, Blue Book, and Dictionary of International Biography. His most recent book, Beachheads in Space, was published by Macmillan in May, 1983, following his widely acclaimed book on the space shuttle, Enterprise (William Morrow).

Mrs. LLOYD. Thank you, Dr. Grey.

Mr. Schmidt.

STATEMENT OF CHARLES A. SCHMIDT, VICE CHAIRMAN AND GENERAL MANAGER, ASTRO-SPACE DIVISION, GENERAL ELECTRIC, ACCOMPANIED BY DR. J.S. ARMIJO, PROGRAM GENERAL MANAGER, SP-100 PROGRAMS

Mr. SCHMIDT. Good afternoon, Madam Chairman, Members of the Committee. I have accompanying me today Mr. Sam Armijo who is the Program General Manager for the SP–100 program.

Mrs. LLOYD. Mr. Armijo, we are happy to have you with us as well.

Mr. SCHMIDT. I am Charles Schmidt, Vice President and General Manager of G.E.'s Astro-Space Division. Our organization has designed, fabricated, and launched 163 military, scientific and commercial satellites for the U.S. and overseas customers.

In the field of nuclear-powered systems, we have designed and fabricated radioisotope thermoelectric generators for 10 successful missions, including Apollo and Voyager, and are proud to be supplying the RTGs for the upcoming Galileo mission to Jupiter later this year.

We are also the lead system contractor for the nation's SP–100 Ground Engineering System program. This past September I presented testimony on SP–100 to the Senate Committee on Energy and Natural Resources and I request that it be entered into the record of these hearings.

Mrs. LLOYD. Without objection, it will be made a part of the record.

Mr. SCHMIDT. Whereas that testimony emphasized safety, I will focus these comments on the need for SP–100, the validity of the technology, and the necessary actions by the government to assure the timely completion of this program.

The U.S. must keep a steady course on SP–100 or accept a subordinate role in space in the 21st century. This conclusion is based on the following points.

The need for nuclear reactor power in space is becoming increasingly more evident as future NASA and DOD missions become better defined. The Presidential Directive on National Space Policy, signed on January 5, 1988, establishes a thrust to maintain space leadership with the long-range goal to extend human presence and activity beyond earth orbit into the solar system.

NASA planners are evaluating key missions to achieve this national goal. Those requiring nuclear powered systems include manned lunar outposts, lunar and earth orbiting material processing facilities, and large electrically powered interplanetary cargo vehicles.

Defense missions will also demand highly survivable power from kilowatts to multimegawatts for high performance space based radars and surveillance systems.

In contrast to the U.S., the Soviets have orbited approximately 30 nuclear reactor powered satellites. Recent announcements by Soviet space nuclear power experts indicate that they are continuing their space nuclear program to develop systems for higher powered spacecraft. The Soviet space nuclear power program has not faltered since the U.S. and Soviet programs were initiated over 25 years ago. While we terminated our program in the early '70s, the Soviets pressed on and are reaping the benefits with their Radar Ocean Reconnaissance Satellites or RORSATS.

If we complete SP-100 and its follow-on flight demonstrations, the U.S. will have the option to deploy space nuclear power systems and high power mission payloads which will surpass current and perhaps future Soviet systems. Without its development, the U.S. will not have this option.

The Department of Energy, the Department of Defense and the National Aeronautics and Space Administration jointly reinitiated the development of a U.S. space nuclear reactor power system in the early 1980s. The government selected the SP-100 technology after a rigorous and open evaluation of all competing concepts. The selection of the liquid metal cooled fast reactor with thermoelectric power conversion was made because it best met key safety, reliability, scalability and flexibility requirements with minimum development risk. It should be pointed out that the operational Soviet RORSATS are also liquid metal cooled fast reactors with thermoelectric power conversion systems.

Substantial progress has been made on this project. The nation has assembled a highly qualified and dedicated space nuclear power system design and test team. The team, composed of industry and national laboratory sites in nine states supported by key vendors and universities, is working well and hardware is coming out of the development pipeline.

SP-100 has suffered schedule slippage driven by chronic funding shortfalls. This can be solved by stable and adequate funding. The time to take action is now. Stable funding of $95 million per year through 1993 and lesser amount thereafter is needed to complete the ground engineering system by 1995. This level of funding already represents a four-year delay from the original plan, but it will provide the U.S. with a nuclear power option to meet NASA and DOD high power missions projected for the turn of the century.

The United States must not accept a subordinate role in space. Working together, the Congress, the Administration and industry can keep SP-100 on a steady course and provide the electric power required for leadership in space in the next century.

Thank you.

[The prepared statement of Mr. Schmidt follows:]

STATEMENT OF

C. A. SCHMIDT
VICE PRESIDENT AND GENERAL MANAGER
GE ASTRO-SPACE DIVISION
PRINCETON, N. J.

BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
U. S. HOUSE OF REPRESENTATIVES

MARCH 1, 1989

STATEMENT OF C. A. SCHMIDT
VICE PRESIDENT AND GENERAL MANAGER
ASTRO-SPACE DIVISION
FOR THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

Good morning Madam Chairman and members of the Committee. I am Charles Schmidt, Vice President and General Manager, of the GE's Astro-Space Division. Our organization has designed, fabricated and launched 163 military, scientific and commercial satellites for U. S. and overseas customers. In the field of nuclear powered systems we have designed and fabricated Radioisotope Thermoelectric Generators (RTG's) for ten successful missions including Apollo and Voyager and are proud to be supplying the RTG's for the upcoming Galileo mission to Jupiter later this year. We are also the lead system contractor for the nation's SP-100 Ground Engineering System Program.

This past September, I presented testimony on SP-100 to the Senate Committee of Energy and Natural Resources and I request it be entered into the record of these hearings. Whereas that testimony emphasized Safety, I will focus these comments on the need for SP-100, the validity of the technology, and the necessary actions by government to assure the timely completion of the program.

The U. S. must keep a steady course on SP-100 or accept a subordinate role in space in the 21st century. This conclusion is based on the following points.

The need for nuclear reactor power in space is becoming increasingly more evident as future NASA and DOD missions become better defined. The Presidential Directive on National Space Policy, signed on January 5, 1988, establishes a thrust to maintain space leadership with the long range goal "to extend human presence and activity beyond Earth orbit into the solar system".

NASA planners are evaluating key missions to achieve this national goal. Those requiring nuclear powered systems include manned lunar outposts, lunar and earth orbiting materials processing facilities, and large electrically powered interplanetary cargo vehicles.

Defense missions will also demand highly survivable power from kilowatts to multimegawatts for high performance space based radars and surveillance systems.

In contrast to the U. S., the Soviets have orbited approximately 30 nuclear reactor powered satellites. Recent announcements by Soviet space nuclear power experts, indicate that they are continuing their space nuclear program to develop systems for higher powered spacecraft. The Soviet space nuclear power program has not faltered since the U. S. and Soviet programs were initiated over 25 years ago. While we terminated our program in the early 70's the Soviets persevered and are reaping the benefits with their radar ocean reconnaissance satellites (RORSATS).

If we complete SP-100 and its follow-on flight demonstrations, the U. S. will have the option to deploy space nuclear power systems and high power mission payloads which will surpass current and perhaps future Soviet systems. Without its development, the U. S. will not have this option.

The Department of Energy, the Department of Defense and the National Aeronautics and Space Administration, jointly reinitiated the development of a U. S. space reactor power system in the early 1980's. The government selected the SP-100 technology after a rigorous and open evaluation of all competing concepts. The selection of the liquid metal cooled fast reactor with thermoelectric power conversion was made because it best met key safety, reliability, scalability and flexibility requirements with minimum development risk. It should be pointed out that the operational Soviet RORSATS are also liquid metal cooled fast reactors with thermoelectric power conversion systems.

Substantial progress has been made on this project. The nation has assembled a highly qualified and dedicated space nuclear power system design and test team. The team, composed of industry and national laboratory sites in nine states supported by key vendors and universities, is working well and hardware is coming out of the development pipeline.

SP-100 has suffered schedule slippage driven by chronic funding shortfalls. This can be solved by stable and adequate funding. The time to take action is now. Stable funding of $95 million per year through 1993 and lesser amount thereafter is needed to complete the ground engineering system by 1995. Although this reduced funding level represents a 4 year delay from the original plan, it will provide the U. S. with a nuclear power option to meet NASA and DOD high power missions projected for the turn of the century.

The United States must not accept a subordinate role in space. Working together, the Congress, the Administration and industry can keep SP-100 on a steady course and provide the electrical power required for leadership in space in the next century.

SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
CHAIRED BY BENNETT JOHNSTON

TESTIMONY OF
MR. CHARLES A. SCHMIDT
VICE PRESIDENT AND GENERAL MANAGER
GE ASTRO-SPACE DIVISION

P.O. BOX 800
PRINCETON, NJ 08540

SEPTEMBER 13, 1988

Statement of C.A. Schmidt
Vice President and General Manager,
GE Astro-Space Division
before the
Senate Committee on Energy and Natural Resources
September 13, 1988

Introduction

Good morning Mr. Chairman and members of the Committee. I am Charles Schmidt, Vice President and General Manager of GE's Astro-Space Division. I am pleased to have this opportunity to testify before your committee. My written testimony has been provided to your staff and I request that it be entered into the record of these hearings. Since GE is the systems contractor for SP-100, I will focus my comments on the SP-100 Program and in particular, the key safety features being implemented.

THE NEED FOR NUCLEAR REACTORS IN SPACE

It is becoming increasingly evident that our nation's continued leadership in space will require nuclear reactor power. Many ambitious space missions of the future required to assure this leadership will need a reliable source of electrical energy that exceeds the capabilities of current technology. While nuclear Radioisotope Thermoelectric Generators (RTG's) and solar systems can provide watts to kilowatts of power, reactor based power systems are necessary to support missions requiring tens of kilowatts to hundreds of kilowatts. Nuclear reactor systems also provide independence from the sun, long life and increased survivability advantages.

THE SP-100 PROGRAM

The United States, under sponsorship of the Department of Energy, the Department of Defense and the National Aeronautics and Space Administration, is developing SP-100 space reactor power system technology to meet the projected civilian and defense needs for the 1990's and beyond. SP-100, will remove the restrictions on electrical power generation that have limited space missions and will enable the fuller exploration and utilization of space. GE, as the systems contractor, is supported by Westinghouse and ThermoElectron, eight of our nations key government laboratories and several hundred subcontractors and vendors across the country.(Reference Figure 1) GE and its team members are committed to making SP-100 space nuclear power a success. We have made and are continuing to make investments in new production and laboratory facilities to assure timely development of the technology and our ability to support future flight options.

Before I address the specific safety aspects of the program, I would like to briefly bring you up to date on the design characteristics of the system and its present state of development. The SP-100 power system (Reference Figure 2), converts heat generated within a compact liquid metal cooled fast spectrum nuclear reactor directly into electricity through the use of thermoelectric conversion. Liquid metal cooled fast reactors have operated safely in this country and around the world for many years. For example, the EBR-II reactor in Idaho has been operated very successfully for over 20 years. We are capitalizing on this solid technology base. Thermoelectric conversion technology, used on SP-100, is also based on over 20 years experience. This technology was used with great success in powering experiments placed on the moon on the Apollo Program in the early 1970's.

In the SP-100 design, the heated liquid metal coolant is pumped from the reactor through a closed heat transfer loop to the thermoelectric modules. Excess heat is rejected to space by heat pipe radiator panels. An important feature is the modularity designed into the system to enhance scalability for specific missions throughout the 10's to 100's of kilowatt range of interest, without the need for new technology.

Substantial progress has been made on this project. This past May, we successfully completed a system design review by nuclear, aerospace, safety and reliability experts from government and industry. Nuclear fuel pellet fabrication development has been completed and manufacturing of fuel for a nuclear system test is currently underway at DoE's Los Alamos National Laboratory in New Mexico. Fuel life tests and core physics experiments are being conducted in DoE reactors in Washington and Idaho. Tests to date have been very successful. High temperature materials development is being conducted at DoE's Oak Ridge National Laboratory in Tennessee, NASA's Lewis Research Center in Ohio and at GE and Westinghouse facilities in California and Pennsylvania. Finally, there has been major progress in preparing facilities at DoE's Hanford laboratory in the State of Washington, for key nuclear system tests in 1992.

Significant progress is also being made in the development of advanced thermoelectric convertors, materials and insulators at GE facilities in Pennsylvania and at ThermoElectron facilities in Massachusetts. Heat pipes, capable of being mass produced, have been successfully tested in GE laboratories in Valley Forge.

Major subsystems and components will be tested on the ground in a simulated space environment to demonstrate compliance with safety, reliability and performance requirements. Major modules of the power system, including the thermoelectric power conversion and heat rejection subsystems are planned for testing as an integrated assembly in a large vacuum chamber at GE facilities in Pennsylvania in 1994.

SPACE NUCLEAR POWER SAFETY

GE has had a major role in space nuclear power programs for more than twenty years. Safety is and will continue to be of utmost importance to GE in the design, development, test and flight of space nuclear power systems. To date, the United States has launched 38 Radioisotope Thermoelectric Generators and one reactor. We should recognize the reliability and safety record of the RTG's which have provided power for key United States missions, including the Apollo manned lunar missions and the recent flyby explorations of Mars, Jupiter, Saturn and Uranus. The Voyager spacecraft is in its 11th year in space and presently over 2 billion miles from earth on its way to Neptune. Without this nuclear technology, this mission could not have been accomplished. RTG's are soon to power the Galilec and Ulysses science missions.

The Government, through the Interagency Nuclear Safety Review Panel, evaluates each proposed U.S. launch involving a space nuclear power system to provide an independent and final confirmation of the safety of the system. This process has been instrumental in the excellent safety record achieved. This same process would be implemented on the SP-100 flight program.

THE SP-100 SAFETY PROGRAM

At the onset of the SP-100 Program, the government, represented by DoE, DoD and NASA personnel as well as National Laboratory experts began developing a comprehensive set of Safety Requirements. These requirements were based on experience from the U.S. RTG missions, the SNAP-10A and Soviet space nuclear programs an well as extensive terrestrial nuclear and spacecraft mission experience including the deliberations of the UN Working Group on the Use of Nuclear Power in Space. These safety requirements were extensively reviewed by industrial participants including GE and Westinghouse and by independent experts. This process has resulted in a set of safety requirements and strategies now in use on SP-100 that assures the primacy of safety to the public, as well as protection of the environment, and the safeguarding of the special nuclear material.

The approach used to implement safety on the program consists of two main elements. The first is to identify the hazards and to incorporate features that are designed and tested to prevent accidents involving these hazards. The second element focuses on selecting the basic design and operational parameters to make the radiological consequences of postulated accidents a small fraction of natural background radiation. These consequences are summarized in Figure 3. This process has resulted in features that are an integral part of the design to ensure safety throughout all mission phases.

The basic safety requirements for SP-100 are as follows:

1. The reactor is to be kept free of hazardous radioactive materials until its prescribed operational orbit is achieved. To accomplish this, the reactor core will not

operate or generate radioactivity prior to achieving the prescribed orbit. The core is designed to prevent criticality under launch and ascent failure modes. A secure command and control communications system will be provided to prevent unauthorized startup and operation.

2. Orbits to be selected for the initial flights will provide time for decay of radioactive material to negligible levels before reentry could occur. While reentry of the reactor from a long life orbit would not constitute a radiological hazard, the SP-100 design approach allows for boosting of the spent reactor to a disposal location in space.

3. The reactor will be designed to return to a subcritical state and remain subcritical and intact even after accidental reentry and impact.

We have developed the generic flight system design with safety features based on these requirements. We have evaluated all mission phases including assembly, transportation, launch, ascent, transfer to operational orbit and end of mission disposal, and assessed the adequacy of the design. We have concluded the system will be safe.

I would like to describe some of our key safety features (Reference Figure 4). Two independent nuclear control features have been incorporated into the SP-100 design to ensure that the reactor remains inoperable until in its planned orbit. These systems will be designed to prevent operation of the reactor if launch accidents were to occur. Until operation, no radioactive materials are generated, and during operation radioactive materials are contained in the reactor and are above the earth's atmosphere and pose no hazard.

The reactor is also designed to retain structural integrity for all credible accidents in space. After completion of its mission, permanent shutdown features have been incorporated and the natural decay of radioactivity to negligible levels would occur prior to the spacecraft's natural orbital decay. As stated earlier, this would constitute no nuclear hazard. If the system were to accidentally reenter the earth's atmosphere, it will remain inoperable and survive reentry and impact essentially intact, through the use of high temperature structural materials and a reentry shield specifically designed for this purpose.

Our safety experts conclude that the radiological consequences of planned as well as unplanned SP-100 events will be very small. For example, if an SP-100 reactor operates at full power and subsequently reenters the earth's atmosphere after a 300 year orbital decay, the radiation exposure to a person standing 3 feet away from the reactor for an hour would be less than a chest x-ray.

I can say with confidence that adherence to the safety design and operational strategy and requirements of the SP-100 program will result in power systems that can be safely used in space. The design, testing and safety review process established for application to the SP-100 program will provide this assurance. Within the program there is an Independent Safety Advisory Committee comprised of nuclear and aerospace safety experts drawn from universities, industry, National Laboratories and private institutions. This group participated in critiquing the safety aspects of the SP-100 system in a major design review this past May. In addition GE has established its own separate Safety Advisory Board to provide independent counsel to management. We would not conduct a program without taking every step to assure human safety. To do otherwise would risk our Corporate reputation. Safety on the SP-100 Program stands alone as a primary objective and GE is committed to relentlessly pursue a safe design.

IMPLICATIONS OF COSMOS 1900

Before I conclude, I would like to take a brief moment to address the Soviet space reactor situation, specifically the possible reentry of Cosmos 1900 reactor and what impact such an event may have and more appropriately should have on the U.S. SP-100 Program.

Reentry of this reactor from space quite naturally will raise the attention and concern of the public. The U.S. Government and industry not only must clearly communicate the benefits of nuclear power and its importance to space leadership, but provide convincing evidence that the U.S. program has important differences as contrasted with the Soviet program; differences which provide significant safety improvements.

Cosmos 1900 has operated in a short lived low orbit and has lost communications with the ground and the reactor may reenter in the near future. In contrast, initial SP-100 flights will not be operated until a prescribed orbit is achieved that assures radioactive material decay to negligible levels. In addition, an extended lost of communications would cause reactor shutdown. We believe these features constitute a significant difference between future use of SP-100 and current Soviet application of space nuclear power.

Cosmos 1900 would be the 3rd Soviet reactor to reenter. The Soviets continue to employ reactors in space and we should fully expect them to continue. They have a need that is best met by nuclear reactors and they are reaping the benefits that can be achieved by their use. Notwithstanding proposals of independent Soviet scientists and others to ban use of reactors in orbit, it is our understanding that the Soviets have had a vigorous space reactor program for many years and that their work in this area will continue.

CONCLUSIONS

In conclusion, I would like to restate our conviction that there is a need to develop a space reactor power capability as a national resource for the United States. SP-100 technology can provide power for space radars and surveillance satellites for military and civilian applications. Global communications can be enhanced, including the use of high power for direct broadcast satellites for total world accessibility. Power for materials processing on space platforms is afforded. Survivable power requirements associated with defense platforms is provided. Power can also be made available for exploration and establishment of manned bases on the lunar and Martian surfaces.

The SP-100 Ground Engineering System Program involves several years of systematic design, ground testing and analysis to properly develop and validate the materials and systems technologies for space nuclear power. Thus SP-100 is an enabling program that will establish a U.S. option to deploy follow-on flight systems yet in this century.

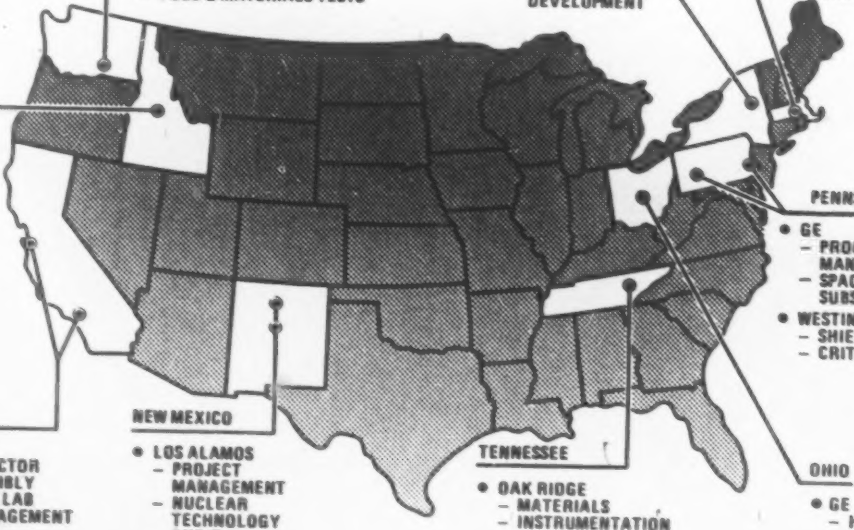
I want to reiterate, that GE and our SP-100 team members remain fully committed to the safe and successful development of this technology and continue to stand ready to serve the Department of Energy, Department of Defense and NASA in meeting future space power needs. We are convinced that safety is being assured in SP-100 through stringent requirements, good design, thorough testing and open review. We would like to count on Congressional leadership to bring these efforts to fruition.

Thank you for allowing me to present this brief overview of SP-100 and its important safety aspects to you. I will be happy to answer any questions which you may have.

SP-100 NATIONAL EFFORT

PRIMARY PARTICIPANTS

SP-100 HAS
OVER 500 VENDORS
IN 27 STATES



WASHINGTON

- HEDL (Westinghouse)
  - NUCLEAR ASSEMBLY TEST
  - FUEL & MATERIALS TESTS

IDAHO

- ANL
  - CORE CRITICALS
  - FUEL TESTS

CALIFORNIA

- GE
  - NUCLEAR REACTOR DESIGN/ASSEMBLY
- JET PROPULSION LAB
  - PROJECT MANAGEMENT (OVERALL & SPACE SYSTEMS)
- ETEC (Rockwell International)
  - LIQUID METAL TECHNOLOGY
  - INSTRUMENTATION

NEW MEXICO

- LOS ALAMOS
  - PROJECT MANAGEMENT
  - NUCLEAR TECHNOLOGY AUDIT
  - FUEL MANUFACTURING
- SANDIA NATIONAL LAB
  - RAD HARD ELECTRONICS

NEW YORK

- GE
  - INSULATOR DEVELOPMENT

MASSACHUSETTS

- THERMO ELECTRON CORP.
  - THERMOELECTRICS
  - MATERIALS

PENNSYLVANIA

- GE
  - PROGRAM MANAGEMENT
  - SPACE SUBSYSTEMS
- WESTINGHOUSE
  - SHIELD
  - CRITICALS

TENNESSEE

- OAK RIDGE
  - MATERIALS
  - INSTRUMENTATION

OHIO

- GE
  - HEAT PIPE WELDING

FIGURE 1

DEPLOYED CONFIGURATION

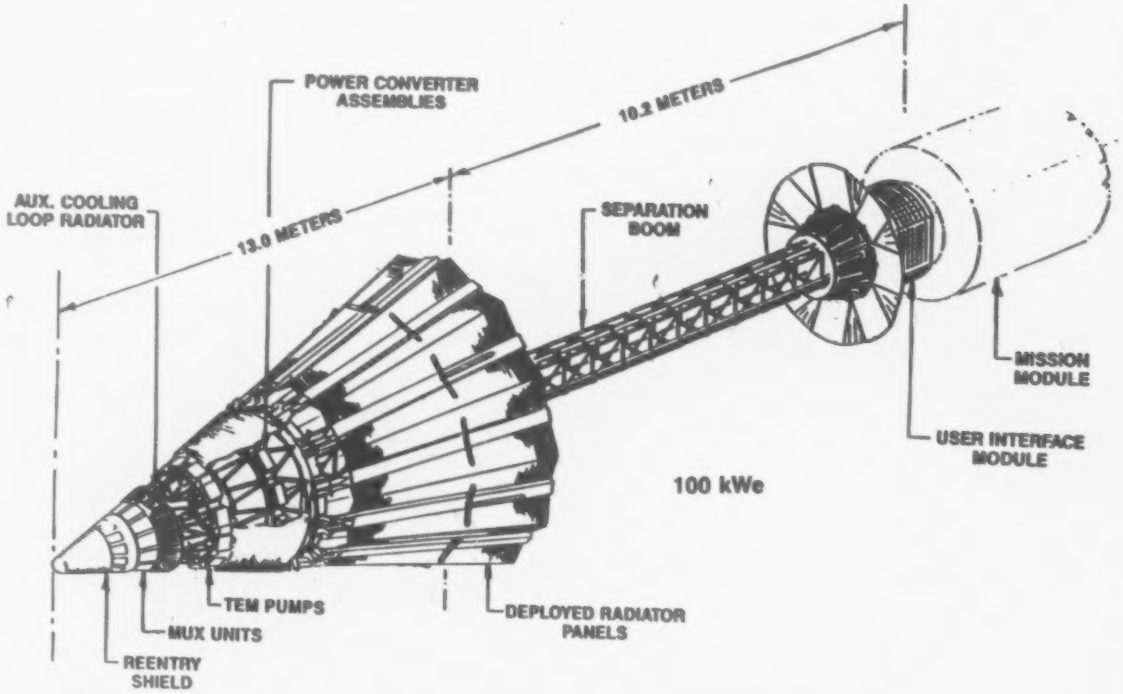

POWER CONVERTER ASSEMBLIES
10.2 METERS
AUX. COOLING LOOP RADIATOR
13.0 METERS
SEPARATION BOOM
MISSION MODULE
USER INTERFACE MODULE
100 kWe
TEM PUMPS
MUX UNITS
REENTRY SHIELD
DEPLOYED RADIATOR PANELS

FIGURE 2

RADIATION CONSEQUENCES OF POSTULATED SP-100 ACCIDENTS

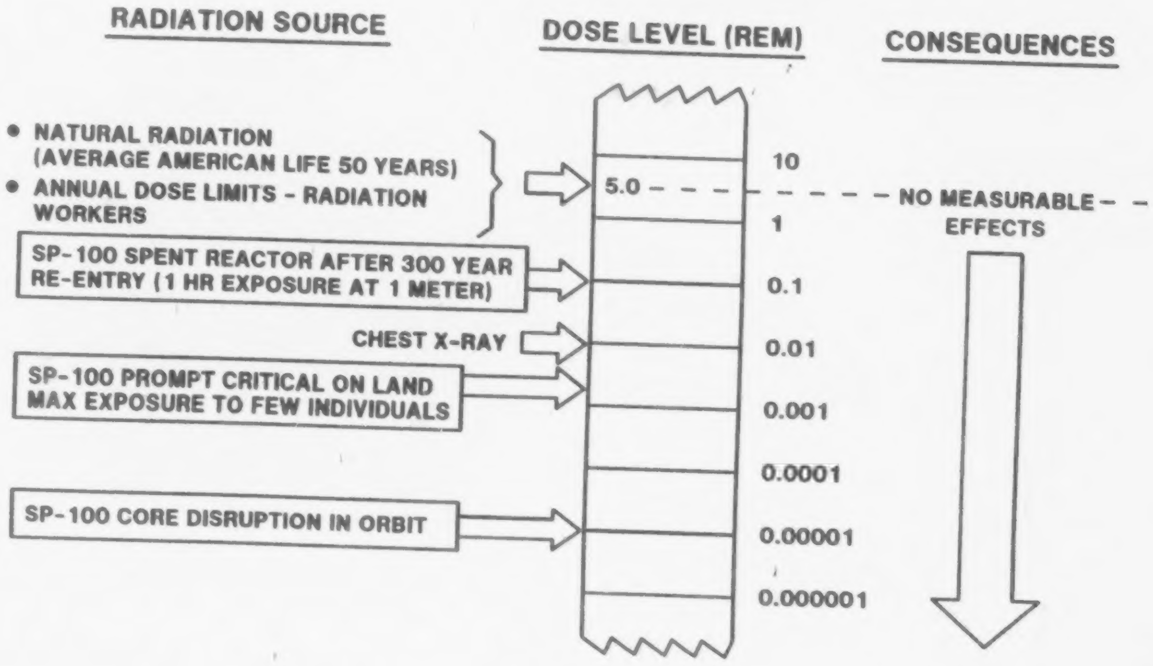
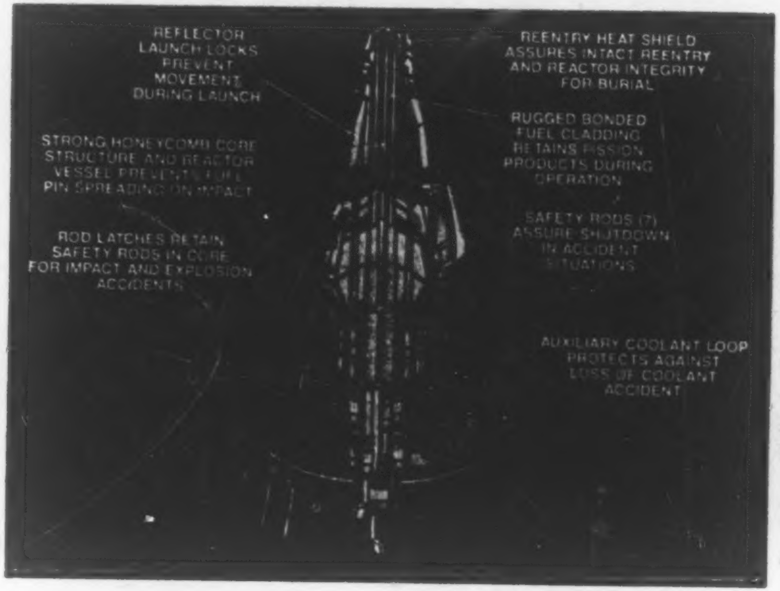

RADIATION SOURCE
DOSE LEVEL (REM)
CONSEQUENCES
• NATURAL RADIATION (AVERAGE AMERICAN LIFE 50 YEARS)
• ANNUAL DOSE LIMITS - RADIATION WORKERS
SP-100 SPENT REACTOR AFTER 300 YEAR RE-ENTRY (1 HR EXPOSURE AT 1 METER)
CHEST X-RAY
SP-100 PROMPT CRITICAL ON LAND MAX EXPOSURE TO FEW INDIVIDUALS
SP-100 CORE DISRUPTION IN ORBIT
10
5.0
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
NO MEASURABLE EFFECTS

FIGURE 3

KEY SAFETY FEATURES


REFLECTOR LAUNCH LOCKS PREVENT MOVEMENT DURING LAUNCH
STRONG HONEYCOMB CORE STRUCTURE AND REACTOR VESSEL PREVENTS FUEL PIN SPREADING ON IMPACT
ROD LATCHES RETAIN SAFETY RODS IN CORE FOR IMPACT AND EXPLOSION ACCIDENTS
REENTRY HEAT SHIELD ASSURES INTACT REENTRY AND REACTOR INTEGRITY FOR BURIAL
RUGGED BONDED FUEL CLADDING RETAINS FISSION PRODUCTS DURING OPERATION
SAFETY RODS (7) ASSURE SHUTDOWN IN ACCIDENT SITUATIONS
AUXILIARY COOLANT LOOP PROTECTS AGAINST LOSS OF COOLANT ACCIDENT

- **CONTROL ELEMENTS AUTOMATICALLY SHUT REACTOR DOWN UPON LOSS OF POWER**
- **TWO INDEPENDENT SHUTDOWN SYSTEMS**
- **PROMPT NEGATIVE REACTIVITY COEFFICIENT ASSURES STABLE REACTOR CONTROL**
- **ONLY 4 OUT OF 12 REFLECTORS REQUIRED FOR SHUTDOWN**
- **CLEAN CORE AT LAUNCH**
- **LARGE NEGATIVE VOID COEFFICIENT ENHANCES SHUTDOWN UPON LOSS OF COOLANT**
- **CONTROL ELEMENTS MOVED INDIVIDUALLY AND IN INCREMENTAL AMOUNTS TO PREVENT RAPID REACTIVITY ADDITION**
- **RHENIUM POISON PROVIDES THERMAL NEUTRON ABSORPTION FOR WATER FLOODING**

FIGURE 4

Mrs. LLOYD. Thank you for your testimony, Mr. Schmidt.

PANEL 4 DISCUSSION

Mrs. LLOYD. Charlie, there have been reports in the media that a government audit showed that SP-100 was designed beyond its data base, that it wasn't meeting the mass or survivability goals and has serious technical problems.

Are these reports accurate? What is the status of these issues?

Mr. SCHMIDT. I think the report that you referred to was in a New York Times article on February 9, and it was neither correct nor complete.

Mrs. LLOYD. Has there been a rebuttal to the article? Has there been one?

Mr. SCHMIDT. Not that I am aware of, no.

The article claimed a government audit was performed which discovered serious technical deficiencies. The fact was, the report cited was not from a government audit but a normal in-progress SP-100 program system design review. This review was held in May 1988 and was commissioned to evaluate the flight design at a point in time and not a final design.

The media article selectively cited negative findings from the design review report but none of the positive findings. In these kind of design review meetings it is perfectly normal that things are pointed out that are not sufficient and that's the purpose of the meeting.

The independent review board was pleased with the approach to reactor safety. In particular, the emphasis on nuclear safety in both design and presentation were strong points. The article claimed the design was based on extrapolations beyond our data base. This is true but it's misleading. In the development of advanced systems, designers routinely make reasonable extrapolations of data and initiate test programs to confirm those extrapolations.

In the case of SP-100, recent fuel performance tests, material properties tests, and nuclear control and safety tests are confirming these extrapolations and testing will continue.

The article identified the mass of the system to be 6 tons, which was correct but failed to mention that practical means for achieving a substantially lower mass were identified in the design review. Since the time of that review, the mass has been reduced to 4.8 tons and we have identified options to yet further reduce the mass to the project goal of 4.4 tons.

Mrs. LLOYD. As you know, the Administration has proposed cutting the program by $15 million below the '89 levels. How would this impact your personnel and your schedules and the project costs?

Mr. SCHMIDT. Well, I think—I forget the number—but it's either five or six times we've already reprogrammed SP-100 and we've had several reductions in force, and they seem to come just after we get a force up to the level that the plan calls for.

I think this has very serious effects on all programs, not just nuclear programs. Whenever there is a funding shortfall, the only answer is to do one of two things: reduce the scope—and there are not too many things that you can truly reduce the scope in this program because safety has to be the paramount issue—or you can elongate the program and just have it run for more years. And in the end, the price is materially increased just by the stretching out of the program because you've got to carry your standing army during that extra time, and it just costs more money, and it doesn't make any difference what kind of program it is; it happens every time.

Mrs. LLOYD. And then your program is characterized as being too expensive.

Mr. SCHMIDT. Yes. And they say, look, when it started out it was an X program, and you guys now spent 2X. Right.

Mrs. LLOYD. Charlie, I would like to encourage you to write a reply to the New York Times article or have someone do that.

Mr. SCHMIDT. All right, we'll go back and work on it.

Mrs. LLOYD. That might be a good idea.

Mr. Grey, as you know, there are many groups that argue that we should prohibit the use of space nuclear systems in our earth orbit and that the Soviets might be agreeable to the signing of a mutual agreement to ban the use of nuclear power systems in Earth's orbit.

Do you think the Soviet Union would be agreeable to such an agreement?

Dr. GREY. I would be very surprised if they were. There are factions within the Soviet Union—some of the scientific groups have indicated that they would like to see reactors banned from orbit—but I can only cite to you the behavior of five Soviet engineers who appeared at our Albuquerque meeting in January, and they were very eager to encourage the U.S. to participate in their activities.

The indication there was that they planned to expand rather than reduce what they've been doing so far. As in this country, of course, there are some people who say no, we should get rid of all nuclear power plants in orbit. But I do not think the Soviet Union plans any such activity.

Mrs. LLOYD. This is not the philosophy of the leadership?

Dr. GREY. It does not appear to be. They seem to be stressing the continued development, in fact the growth of nuclear power systems, and I think some reviews by people in our Department of Defense have corroborated that.

Mrs. LLOYD. Dr. Korenko, would you care to comment further?

Dr. KORENKO. With respect to the Soviet involvement, I really wouldn't care to comment on that because I don't have any direct interaction. But our people have met with the same Soviets, same conference, and confirmed that in fact they were enthusiastic and expanding, and they are proud of the fact that they have had a continuous effort whereas in this country, even though we had the lead, we dropped the ball again and they picked up the marbles.

So that kind of rankled us a bit, to tell you the truth, because now the SP-100 is in a situation where we have to really reconfirm our national resolve and really just bet on this horse.

Maybe one comment. There has been a little bit of—some negative innuendoes, I guess, toward the Department of Energy during this conference. But in terms of this particular program, the SP-

100, I think it really is being well managed. And if there is a kudo to put on record, I think this one is really doing a good job.

Ironically, though, if the funding starts eroding and the Department of Energy is forced to make these difficult choices, they will probably be blamed for "mismanagement." And that really isn't true.

I think that everybody is pulling together and trying to bring the funding to bear. It hurts in a lot of ways. For example, we are trying to procure a vacuum vessel. It has taken us months to get this into the system. If we delay it, all of a sudden, boy, we've lost a lot.

The people on the project, they want to start it and complete it. They don't want to make it a lifetime employment effort to do a project that slipped. So just from the troops, the message is let's get on with it, let's do it, and then go on to something else.

Mrs. LLOYD. As you know, this Subcommittee has been a friend of the SP-100 program for many years before the SDI program. We've been around a long time.

Dr. Armijo, do you have any comments you'd like to share with us, any thoughts you'd like to share with us?

Dr. ARMIJO. Thank you, Madam Chairman.

I'd like to second Mike Korenko's message. We have worked with the national laboratories in a very cooperative and very efficient manner on SP-100 and there has been tremendous performance, swimming upstream against constant budget cuts at Los Alamos, at Westinghouse-Hanford. We've had support from Oak Ridge on materials and technology and also from ETEC.

Some day we'd like to have the opportunity to present the accomplishments of the program, and there are many in advanced technologies.

The other thing I'd like to add is that SP-100 technology is truly the right technology. The operating RORSATS systems, as Mr. Schmidt mentioned, are low-tech versions of the SP-100 technology. That's what the Soviet Union is flying today and that's what they will continue to fly.

The thermionic design which was mentioned is an experimental unit that's been 25 years in development and is not their operational system. We don't know what their advanced operational system will be, but my opinion would be that it will be an SP-100 growth type of system.

That's all I have to say. Thank you.

Mrs. LLOYD. Thank you very much.

Mr. Morrison?

Mr. MORRISON. Gentlemen, everyone seems to want SP-100 but no one wants to pay for it. I tried a little earlier to get the DOE witness to condemn OMB for failing to coordinate all of these activities. I guess out of frustration, the Chairman and I have tried to leverage this in all conceivable ways.

If you have any suggestions on how we might better coordinate. Dr. Grey, your experience is marvelous in this area. Any suggestions on how we do a better job to coordinate DOD, NASA and DOE on getting some bucks out of them?

Dr. GREY. First of all, let me say I think that NASA, DOD, and DOE are very well coordinated in program management on this one, as contrasted perhaps with others. But the management, I think the cooperation is very good.

In terms of getting more money, there is a definite increase this year in both the DOD and NASA support for the program. This morning and in previous hearings before other Subcommittees of this Committee, we have supported very strongly the increase in technology developments at NASA, in their civil space technology initiative and in their Pathfinder program, both of which have strong elements supporting the SP-100 and other nuclear programs.

Now, all we can do is keep pushing. We're hoping that the new Administration may have a strong view in this area and support for the SP-100 program, in fact as we've recommended for accelerating rather than maintaining the present schedule, is critical to the future of this country.

I believe that we should all be working very hard towards getting as much money into it as possible, because unless we put these advanced technology programs in place we foreclose a host of future options. And we just can't afford to do that anymore in this world.

Mr. MORRISON. We tried to take advantage of the Sally Ride initiatives to give us a booster shot, if you will, and haven't done very well.

Any other suggestions, comments? I know, Dr. Korenko, that your troops have a tendency and I'm sure the same thing is true, Mr. Schmidt, with your team at G.E., that their morale gets down a little bit when in fact this program is strung out because everyone who believes in it knows that it is absolutely essential.

Mike?

Dr. KORENKO. I have just one quick comment, just maybe a hope more than anything. We just heard that Admiral Watkins is now Secretary Watkins and there is a lot of hope that he will provide the leadership, and he has the influence to team well with DOD and NASA, so in fact would be instrumental in leveraging dollars that way. So we really are encouraged by his confirmation and look to that as a possible way to increase the funding on important programs.

We know that he has personally asked to have this reviewed within the next two weeks. So although he has other issues all over the Department of Energy, he wants to grab hold of it and look at it. So I think that's a very encouraging sign.

Dr. GREY. I would like to reinforce even more strongly the point that Chairman Lloyd made a few moments ago. That is, the public vision of the use of nuclear power in space is, I'm afraid, a very bad one at the moment.

Frankly, there has been a lot of sensationalist hype in the newspapers, in the magazines, about the dangers and the concerns and what are we going to get from it and those things.

I think your direction, Madam Chairman, to Mr. Schmidt to respond to the New York Times article should not only be left there, but should be expanded considerably. I think the public has no real understanding or appreciation either of the real safety issues or of the real benefits.

Mrs. LLOYD. Dr. Grey, maybe you ought to respond, too.

Dr. **Grey**. I plan to. I write to the New York Times very often and I take exception to what they say. I had not planned to respond to this one, but with your stimulus I probably will.

Mrs. **Lloyd**. I don't mean to be telling you gentlemen what to do. I think you can operate without the Subcommittee giving you directions, but at the same time it seems to me you've got the expertise to take care of the situation.

Dr. **Grey**. The point I am trying to make is I don't think we can lose track of the fact that we must maintain a constant effort to address not only the OMB and the Department of Energy and NASA and DOE, but the public.

And without that, I think we will have a great deal of trouble getting a program supported.

Mr. **Morrison**. No further questions. A good hearing, Madam Chairman. Thank you.

Mrs. **Lloyd**. This was a very good hearing today. I do want to apologize again for being late this morning, but we are on many tracks at this time of year.

I would like to thank the Staff for the excellent job that they have done in putting this hearing together. It takes a lot of time and preparation, and they certainly brought the outstanding witnesses to the witness table as well.

This does conclude our hearing on nuclear fission R&D. The Subcommittee will meet tomorrow afternoon at 1:30 and we will consider the solar energy R&D request from the Department of Energy.

If there are no further comments, the Subcommittee stands adjourned.

[Whereupon, at 4:55 p.m. the hearing was adjourned.]

APPENDIX 1

STATEMENTS FOR THE RECORD

Energy Technology Engineering Center
Rocketdyne Division
Rockwell International Corporation
P.O. Box 1449
Canoga Park, California 91304

Operated for U.S. Department
of Energy

Rockwell
International

March 14, 1989 In reply refer to 88ETEC-DRF-0497

Mr. Lou Ventre
Rayburn House Office Building, Rm 374
South Capital Street & Independence Avenue, SE
Washington, DC 20515

Subject: Correction to Testimony of D. Clark Gibbs, Given March 1, 1989

Dear Mr. Ventre:

In my testimony before the Energy, Research and Development Subcommittee on March 1, 1989, a statement, found on page 5 of the prepared text, that the " . . . California Energy Commission has loaned Exergy about $5 million, . . . " should read: ". . . California Energy Commission has loaned Exergy about $1.5 million, . . ." A corrected text is enclosed.

I regret any inconvenience.

Sincerely yours,

D. Clark Gibbs

D. C. Gibbs, Vice President
& General Manager (Acting)
Energy Technology
Engineering Center

Enclosure as noted

16gb19

STATEMENT OF

D. CLARK GIBBS
VICE PRESIDENT AND GENERAL MANAGER (ACTING)
ENERGY TECHNOLOGY ENGINEERING CENTER
ROCKETDYNE DIVISION, ROCKWELL INTERNATIONAL CORPORATION

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

OF THE

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

Madam Chairman and members of the subcommittee, I am pleased and honored to have the opportunity to meet with you today. I am here today to represent the interests of Rockwell International as the operator of the Energy Technology Engineering Center (ETEC) which is owned by the Department of Energy (DOE). I will not attempt to represent Rockwell's other interests that are applicable to the subject of this hearing.

The DOE intends to reduce the funding for ETEC that is derived from DOE-NE to $7.1M in FY90. This is about $7M less than is required from that source and will, in our opinion, most likely result in the closure of ETEC and the loss of that valuable resource to the nation. My purpose for being here today is to tell you why we think that is a very bad idea, and why our funding requirements are as they are.

ETEC has evolved considerably over the past ten years since the days when it was exclusively a testing center for liquid metal systems and components. It now is a development center that supports or has recently supported many energy technologies including solar, geothermal, fusion, conservation, advanced coal, ocean thermal energy conversion, and light water reactors. Despite the fact that its considerable facilities have a replacement value in excess of $500 Million, it operates on a relatively modest budget of around $30M annually. The degree to which it has diversified is illustrated by its funding sources in FY89. ETEC currently derives 36% of its financial support from DOE-NE, 16% from DOE sources other than NE and 48% from non-DOE sources. This is a far cry from five years ago when 84% of ETEC's funding came from DOE-NE. The DOE-NE funding profile for ETEC for the past 10 years is included herewith as Figure 1.

During its recent history some new facilities have been constructed that are noteworthy. A steam system test facility, currently under construction, will have the capability to test to steam flow rates as high as 9 million pounds per hour - about 10 times greater than any comparable test facility and nearly comparable to the steam flow in a large nuclear plant operating at full power. This facility is being constructed at no cost to DOE-NE. A seismic fragility test system has been installed to test piping systems to destruction under extraordinary seismic conditions. No comparable system exists worldwide. A new test fixture for testing seismic isolators is being installed. A space advanced components engineering facility is partially complete that simulates the space environment and has been provided with a 10,000 KVa power supply and a committed heat rejection system.

Two challenges facing the DOE now that have received much recent attention are the environmental restoration of existing defense sites and the modernization of the production facilities including the design and construction of two new production reactors. On the former, ETEC has accumulated over 20 years of experience in the technique and technology of decontamination and decommissioning. This capability represents a unique resource available to the government for deployment to the effected sites. The experience accumulated by this group should be capable of ensuring that future remediation efforts enjoy the benefit of past lessons learned. On the latter, ETEC's history as a development and test site for new reactor designs and its wealth of installed facilities is ideally suited to provide support at a modest cost for both the HWR and the HTGR.

ETEC's new facilities reflect the dynamics of the changing environment in which ETEC has been successfully operating over the past several years. But despite the added breadth of capability they afford, the crown jewels at ETEC continue to be the large sodium testing facilities, the Sodium Components Test Installation (SCTI) primarily intended for testing steam generators, and the Sodium Pump Test Facility (SPTF). These two facilities are by far the largest such facilities in the world. Furthermore, the SCTI provides the core of operators and engineers around which we can assist the many other interests that call upon us intermittently. Since most of the users of ETEC call for facilities or capability unrelated to the SCTI, only DOE-NE can be relied upon to provide the support necessary to maintain the core in operation. If the core is removed, ETEC will soon thereafter become nonviable when its current work assignments with transient customers are completed.

Our funding from NE in FY89 is $11.4M following five years of precipitous decline from the FY84 level of $31.8M. In FY89 we used $1.5M for SCTI support that had been received from another user of the SCTI that offset DOE-NE costs. Because of the payment schedule of that user, no funds will be received for SCTI operations in FY90, transferring this burden to DOE. In addition, environmental requirements, one of which is a recent change, require that a small amount of additional investment, on the order of 0.6M be made in the SCTI in FY90. Providing another 0.6M for escalation and adding these requirements to the FY89 DOE-NE funding, we arrive at $14.1M as our requirement for FY90. This level of support will be tight, but adequate to permit continued operation of the SCTI through FY90.

Interest in sodium cooled reactors continues to be relatively modest since the Clinch River Breeder Reactor Plant Project was cancelled in 1983. That project enjoyed consensus support from a large fraction of the advocates of the promotion of the use of nuclear power in this country. Its cancellation was a huge disappointment to those advocates, and the effects of that disappointment continue to be experienced today. Nonetheless the basic merits of liquid metal reactor technology have not changed and renewal of substantial support, development, and deployment is as inevitable as day following night.

Liquid metal cooled fast spectrum reactors have long been recognized as offering superior flexibility in deployment options compared with thermal spectrum reactors. First, their high power density causes them to be ideal for space and marine applications. Second, their excellent neutron economy makes then about twice as effective as thermal reactors when operating in the production mode. Third, the chemical and physical properties of the coolant provide the means for achieving an excellent prospect for economy in a well designed plant. Fourth, the high energy spectrum can be used to burn waste actinides, reducing by factors of 1000 or more the long term hazard of disposed high level radioactive waste. Finally, the fast spectrum reactor is the only concept that can be deployed effectively as a breeder.

In addition, by comparison to thermal spectrum reactors, fast reactors are less susceptible to plant aging, offer greater prospects for capitalizing on economics of scale, can be operated for longer periods between refueling, should require substantially less maintenance, and should be far simpler to operate than thermal reactors. They will operate at higher thermal efficiencies reducing environmental impact by requiring less cooling water, and should be easier to construct. Their operation results in much lower radiation exposures to plant workers and should lead to reduced turnover among maintenance personnel. They have won acceptance world wide as the reactor system of choice for the future and have attracted significant development activity in at least ten nations. That activity has solved many of the problems that surfaced in the early period of development of the concept which now spans 38 years. The U. S. alone has over $16 billion of present worth investment in sodium cooled reactors.

While design, construction and deployment of nuclear plants continues abroad, new activity has been temporarily interrupted in the United States. Although the causes of the current hiatus are fairly well understood, one cannot predict with certainty when the demand for nuclear energy in the United States will re-emerge.Recent factors, most notably the media attention and public awareness given to the greenhouse effect, as well as the relatively high rate of load growth among electric utility companies tend to improve the prospects for deployment earlier than might have been expected three years ago after the Chernobel accident. In addition, 1988 was the first year that domestic nuclear plants showed a significant improvement in performance as measured by capacity factor. Also, recent public opinion polls taken by the Council for Energy Awareness suggest that the public is now perceiving an increasing role for nuclear power as the means for electric power generation in the future. One thing that is certain is once the log jam is broken and the first new plant is started, it will be followed by a large number of other plants in short order. The changing conditions which allow one electric utility company to start a plant will apply to them all in much the same way. As soon as this happens, interest in sodium cooled reactors will immediately recur, fueled possibly by price speculation in yellowcake, by general acknowledgement of the basic limitations imposed by domestic uranium availability, or by a desire to capitalize on one of the other performance advantages offered by these reactors discussed briefly above.

If the reasonableness of this scenario is accepted, what path is indicated today? If an LMR design is initiated in the future, it will very likely contain pumps, heat exchangers, instrumentation, valves, and other components similar to those that have been and are being tested at ETEC. It is likely, however, that many of these components will be very different from today's designs and will therefore require testing.

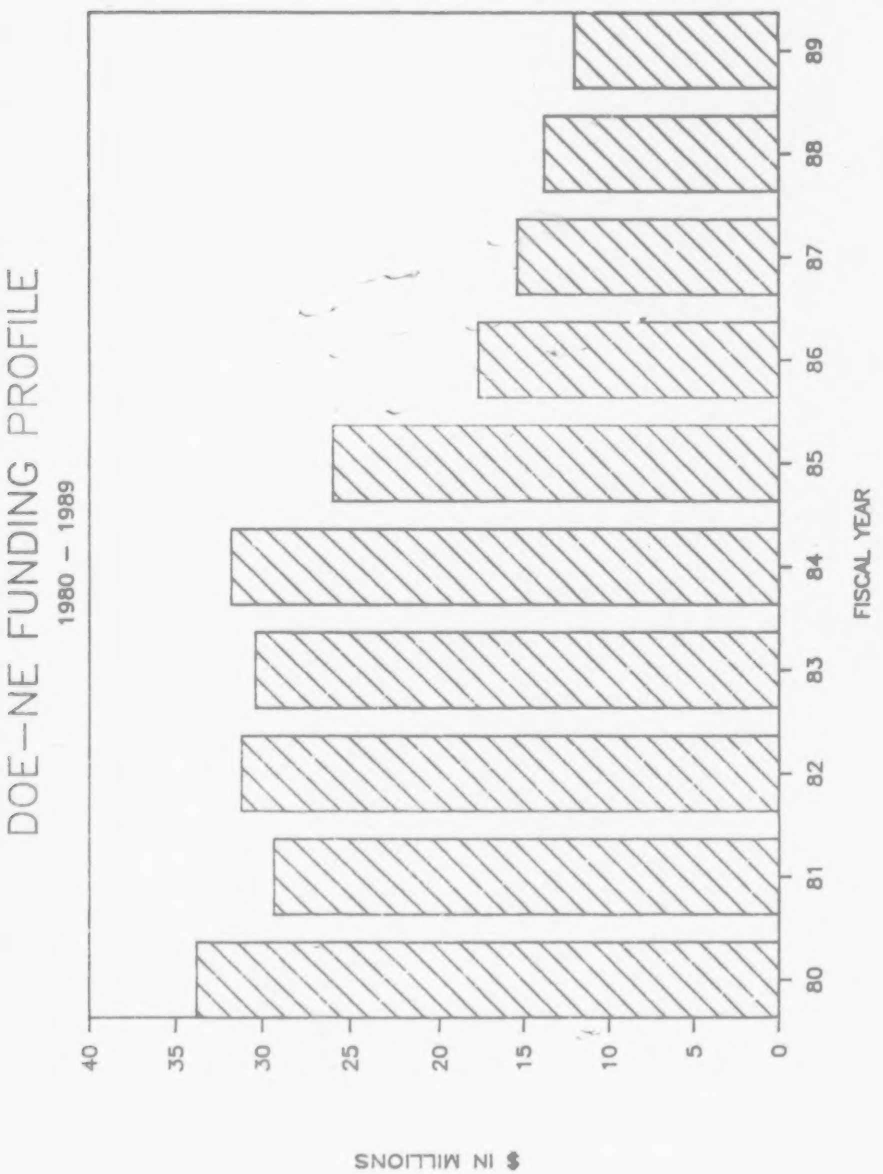
Beyond the need to make occasional minor upgrades, test facilities of the type installed at ETEC are unlikely to become obsolete. Moreover, since the ETEC facilities are not driven by a reactor, change in test article configuration and interface with the facility can be readily accommodated. Failures of the test article during test have no untoward nuclear consequences. Changeout, repair, and reinstallation can be achieved with relative ease since the facilities were primarily designed for testing rather than for design basis nuclear accidents. This logic is a strong argument for the preservation and maintenance of the facilities at ETEC.

If the wisdom of the preservation of the LMR test facilities at ETEC is accepted, how might they be effectively deployed today? An obvious area for current investigation is steam generator testing. Generic issues surrounding steam generator design have been outstanding since the early days of the Fermi reactor and require resolution. Despite the fact that the steam generator is widely acknowledged to be the most difficult design problem with LMRs, there has yet to be any endurance testing of steam generators of a modern U.S. design. The issue of long term steam generator performance is exactly the problem that ETEC had intended to resolve during FY90 with endurance testing of a modern steam generator design at the SCTI. The lessons learned from the endurance testing conducted at ETEC in FY90 will be applicable to sodium heated steam generators of any design.

Endurance testing of steam generators on the SCTI has only recently become practical with the completion last summer of the $15M Power Pak - a cogeneration unit whose generated electric power supplies revenues that offset the fuel and electric costs of operating SCTI. Another recent SCTI improvement is a $2.5M preheater, now under construction, which will improve the thermodynamic efficiency of its associated heater by about 10%. If SCTI is decommissioned now, neither of these recent investments will yield any return and the outstanding Power Pak debt will require settlement.

A steam generator on which a considerable amount of favorable data exists is that which is installed on the EBR-II reactor. A modern design embodying the main feature of the EBR-II design is planned for testing in the SCTI in 1991. This test will last approximately two years and has attracted the financial participation of the Japan Atomic Power Company (JAPC) which will partially offset DOE's costs. JAPC has also expressed an intent and willingness to bear the full cost of utilizing ETEC's Sodium Component Test Loop and its large Sodium Pump Test Facility for subscale tests and full size tests of the sodium pumps it intends for deployment in its Demonstration Fast Breeder Reactor. Another user of the SCTI is Exergy, Inc., which plans to use waste heat to demonstrate a novel thermodynamic cycle using an ammonia-water working fluid. If this demonstration is successful, its promotor, Dr. Alex Kalina, intends to market his product further as a means of generating electricity at significantly higher efficiencies, compared to today's boiler systems. Exergy has attracted both domestic and foreign venture capital to support the planned testing. In addition, the California Energy Commission has loaned Exergy about $1.5 Million, repayable out of a share of the operating cost reduction attributable to the Kalina cycle to be derived from revenues derived from operation of the plant installed on ETEC's SCTI. Exergy has already made significant financial commitments in design and equipment procurement for its intended demonstration at ETEC. Failure to provide adequate financial support for ETEC will inevitably lead to adverse consequences for Exergy, the State of California, and JAPC and will certainly complicate or abrogate DOE's planned efforts to expand its cooperation with JAPC on the Integral Fast Reactor (IFR) studies.

In DOE's budget request for FY90 that supports their proposed $7.1M level of funding for ETEC in FY90, DOE-NE has expressed the intent that additional cost-sharing be obtained from others to match their financial participation. As has been shown in this testimony, ETEC already derives the majority of its support from sources other than DOE-NE. But most of these alternative users of ETEC are interested in facilities or services that do not involve the SCTI, the core of ETEC's operation. Given time, it may be possible to identify SCTI users whose participation at ETEC could gradually reduce DOE-NE's financial participation below even current levels. The British, for example, have recently expressed interest in possible use of the SCTI to test steam generators of their design. But there is not enough time between now and the start of FY90 to achieve such an ambitious goal. It is our conclusion therefore that if the $7.1M DOE-NE funding level is implemented, the result will be the untimely and unfortunate loss of an important national resource which will require major new investments to be made to support near term projects as well as later, when the inevitable rebirth of nuclear occurs.


DOE-NE FUNDING PROFILE
1980 - 1989
$ IN MILLIONS
40
35
30
25
20
15
10
5
0
80
81
82
83
84
85
86
87
88
89
FISCAL YEAR